The Bulletin

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Red Hacker VHF Herald views from front, top and inside.

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Contents

From the Chair

Once again, it is time to write my piece for the Winter Bulletin. This year has passed with astonishing speed. We started off with a special auction in February, followed by all of the usual events. The February Audiojumble was a very busy day and we had no time to even look around before the day was over and everyone was packing to leave. The NVCF was particularly special with a huge display to celebrate our 40th Anniversary organised by Jeremy Day. The display was well received and many requests have been sent in for us to repeat it. Just as the dust was settling, I received a phone call to deal with a deceased member's collection. We were not to know that this would take seven trips and eight van loads to eventually clear. A really excellent Garden party at the Museum and another event at the London Cinema Museum followed. More events and auctions at a rate of one or more a month, another special auction and here we are in November. We have just returned from Golborne and I am already starting to lot up the items for the December Royal Wootton Bassett meeting and auction.

The 2nd of November marked a very significant 80th anniversary of the world's first regular high definition television service. An event was organised by Alexandra Palace which I attended. More on that later in the Bulletin. The BBC commissioned a program to be made which was broadcast on BBC4 that evening, where the presenter (Dallas Campbell) and Dr. Hugh Hunt of Cambridge University and Prof. Danielle George of Manchester University attempted to re-create the first television broadcasts of that day. They took up the challenge of building a replica Baird mechanical spotlight scanner and using very sensitive modern photo cells coupled with modern electronics they achieved a very good result. However practical limitations meant that they could not achieve the full 240 lines. I fear a much bigger budget would have been needed to fully replicate the original Baird equipment. However the EMI 405 line system was achieved with excellent results by use of a camera built by Paul Marshall to operate a pre-war camera tube. The star of the program however was Lily Fry, who as a young girl appeared on television in the first months of broadcasting and showed how she could still tap dance at the wonderful age of 92yrs. The program was interesting and entertaining despite the appearance of a Bush TV22 of 1950's vintage being used to 'look in' which I think was an awful mistake to make when a working pre-war TV was available from the British Vintage Wireless & Television Museum. Later in the Bulletin, you will see how we demonstrated a 1936 television showing both the Baird and EMI systems to those who gathered at Alexandra Palace.

Next year we will be celebrating the 50th anniversary of BBC Colour Television. A special event is currently being planned for this and I will bring you more news and details in the Spring 2017 Bulletin. If you own an early experimental colour TV, studio equipment or ephemera then please do get in touch with me.

I would like to wish you all a very Merry Christmas and a happy New Year!

Mike…

Attention BVWS Members!

The membership card usually supplied with the spring issue of the Bulletin will now be provided separately in the mail during February in time for upcoming events. This will give more time for the Bulletin's production which will now be released in March.

The BVWS at 40 a look back at some highlights

by Lorne Clark

A brief glance back at how it all started and a few highlights along the way. With the limited space available here, this can only be a very brief recap of the origins of our Society. For those who wish to 'dig deeper', I can thoroughly recommend Jonathan Hill's comprehensive book 'The History of the British Vintage Wireless Society 1976 – 1996', pub. British Vintage Wireless Society 1998.

Fig, 1: 1st AGM, 29th May 1977, old '2MT' Marconi Writtle Hut, Chelmsford

How it all began

It is something of an achievement, is it not, that our Society is presently celebrating its 40th anniversary? Forty years since Tony Constable (Fig. 3), on 25th April 1976 at 18 Ravensbourne Gardens, Ealing, hosted the inaugural meeting that was to signal the birth of our society.

The founding Committee comprised A.R. Constable (Chairman and Bulletin Editor), J.A. Gillies (Treasurer), J.E. Hill (Membership Secretary), D.W. Grey, N. Jackson (Bulletin Illustrator) and I.E. Higginbottom. Membership fees were set at a heady £5! Many of you will recognise familiar names here but not, I suspect, D. (Dennis) Grey.

Dennis 'disappeared off the radar' pretty quickly but was, by all accounts, a great 'ideas' man. Here is a short extract from a note he circulated early on, dated 21st June 1976:

"It is already clear that the Society will prosper and will in due course take its place among the established, smaller and specialized institutions of British Industrial history: and will afford pleasure and interest in so doing".

Here, too, is one of his 8 suggested steps or 'OPERATIONS', as part of a proposed 12 to 18 month plan of action: OPERATION 7

We come now to the matter of the kind of vision that the Society ought to have to impress the kind of people that may like to join. Putting the point another way we need to have a social and technical programme that will act as "centres of enthusiasm" for both present and prospective members"
A sentiment as valid today as then...

At a subsequent meeting at Ian Higginbottom's house, 17th April 1977, amongst other business, preparations were made for the first AGM which was, with a keen eye on the past, to be held at the old 2MT Marconi Writtle hut in Chelmsford.

First AGM

The first AGM was held on the windy afternoon of Sunday 29th May 1977 in a wooden hut within the grounds of King's Road School, Chelmsford (Fig. 1). The venue was thoughtfully chosen as this was the very hut, then located in the nearby village of Writtle, from which the experimental transmissions of the Marconi Scientific Instrument Company's 2MT transmitter had been broadcast in February 1922. A display of members' sets was also arranged (Figs. 4&5).

It was at this, the first AGM, that, despite a last minute objection, the name 'The Bulletin' for the society's magazine was confirmed, as was the society's formal name 'The British Vintage Wireless Society'. It was also announced that the Victoria & Albert (V&A) Museum in London were to stage 'THE WIRELESS SHOW', an exhibition of wireless cabinet design from 1922 to 1956. Members were to be asked if they would be prepared to loan sets and a list of sets needed was to be included in the Bulletin Vol. 2 No. 1. The election of the Committee, by nomination and seconding, was then confirmed (Fig. 2).

(Dennis Grey had to reluctantly resign from the Committee owing to pressure of other work.)

It is interesting to review the original constitution of our society, viz:

to promote the study of wireless history

to collate existing sources of information on all aspects of wireless history

to encourage the preservation of early wireless equipment.

So has this changed over the years? Well I suppose the biggest change was the 'expansion' to formally cover television, although, taking the definition of 'wireless' literally, it could be deemed to have already covered television as well. However, a note appeared in a revised Constitution dated March 1992 stating that: "The term 'wireless' is held to include television.".

The BVWS logo

1978 was the year that the BVWS launched a competition to find a suitable society logo. A number of designs were submitted and those attending our 'Winter Wireless Swap' in November 1978 were invited to vote for their favourite. The design in Fig. 6 was chosen, with two other entries shown in Fig. 7. Later versions are shown in Figs. 8 & 9.

1977 BVWS Committee	
Chairman & Bulletin Editor	Tony Constable
Vice Chairman (with secretarial role)	David Read
Treasurer	John Gillies
Membership Secretary	Jon Hill
Overseas Representative	David Brodie
BVWS Artist	Norman Jackson
Technical Officer & External Representative of BVWS	Roger Snelling
Committee Member	Ian Higginbottom

Fig. 2: 1977 BVWS Committee

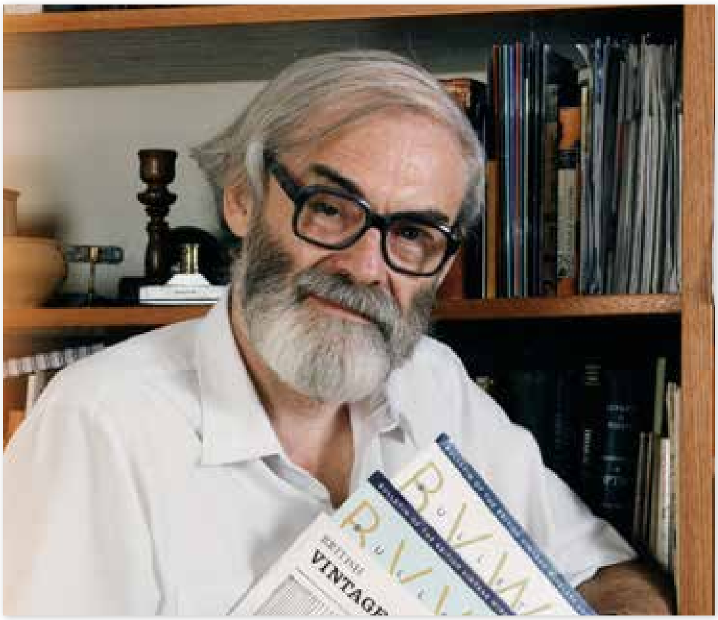


Fig. 3: BVWS founder Tony Constable in 1998.

Fig. 4: View of members' display items at the first AGM, 1977

Fig. 5: Plenty of keen admirers at the display of members' items at the 1st AGM in 1977. Anyone for a game of 'who's who' or 'what's what'? Is that a Magnetic Detector on the table in front of Jonathan Hill (4th from the left)?

Fig. 6: 1978 Logo - The MK I logo designed by Gordon Robinson's son David, winner of the 1978 competition

Fig. 9: 1996 Logo - The MK III logo, introduced in 1996 and still current

Fig. 8: 1986 Logo - The MK II logo, introduced in 1986:

Fig. 7: Two of the other 1978 designs submitted

Collaboration with the V&A

From October to December 1977, the BVWS collaborated with the V&A museum, London, in staging "The Wireless Show", an exhibition focusing on cabinet design of wireless sets from the 1920s to 1950s. Some 130 BVWS member's sets were on display.

BVWS organised exhibition

On 21st and 22nd September 1996, to celebrate the 20th anniversary of the founding of the BVWS, the centenary of Marconi's first patent and 60 years of high definition television, the BVWS staged a major exhibition of wireless sets, televisions, telegraphic equipment and related items at the Public Halls in Harpenden. This really was a top-notch quality display, with working exhibits such as televisions plus numerous beautifully presented display items housed in glass cabinets (see figs. 10, 11, 12 & 13).

Collaboration with the Science Museum, London – Information Age gallery

From June 2011 to October 2014, the BVWS worked with The Science Museum, London, to help develop a new 'Information Age Gallery' to be located in the old Shipping Gallery. Several members of the BVWS were involved in numerous meetings to select items for display and review the layout. During a visit to the Science Museum Reserve Store we found a rare Sargrove receiver, built in 1947 using ECME production equipment, see Fig. 15. Launch of the new Information Age gallery was on 24th October 2014. See Figs. 14, 16 & 17.

BVWS organised exhibition

On 15th May 2016, At the NVCF, the BVWS staged an exhibition of items from BVWS members' collections, some very rare indeed. The result was a most comprehensive and impressive display and images of the items may be found in the Autumn 2016 Bulletin, Vol. 41 No. 3, p24 to p27.

Further reading

If this necessarily short article has whetted your appetite for more information about the early years of the BVWS, I can wholeheartedly recommend 'The History of the British Vintage Wireless Society 1976 – 1996', a comprehensive, well written (from first-hand experience) and lavishly illustrated book by Jonathan Hill, pub. 1998 BVWS. This book is available direct from Mike Barker at the truly bargain price of £5 + £2.85 P&P. Stocks are limited so be quick! Mike's address as follows: Pound Cottage, Coate, Devizes, Wiltshire, SN10 3LG.

Photo Credits
Fig. 1, 4, 5: Andrew Hill
Fig. 3: Susmit Dey
Fig. 10-13: Trefor Ball
Figs. 14 - 17: Lorne Clark

Fig.10: Display of early broadcast receivers

Fig.11: Display of early telegraphic equipment

Fig.12: Display of early mechanical televisors

Fig.13: Display of working vintage televisions

Fig. 14:Members of the BVWS joined 'Information Age' team members from the Science Museum for a meeting at the BVWTM in Dulwich, Sept. 2011. From L-R: Charlotte Connelly (Science Museum), Martyn Bennett (BVWS), Marie Hobson (Science Museum), Lorne Clark (BVWS), John Thompson (BVWS), Deanne Naula (Science Museum).

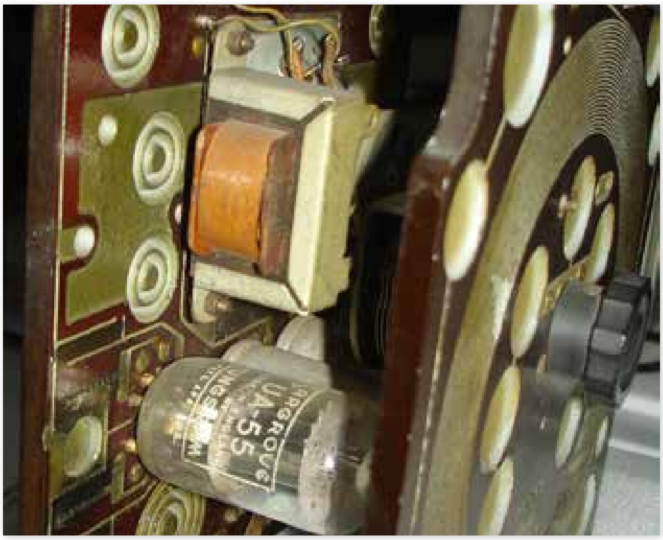


Fig. 15: Rare Sargrove set, minus cabinet, manufactured in 1947 on the ECME automated equipment. See 'ECME' film on BVWS DVD 2008/1, free with Winter Bulletin 2008

Fig. 16: HRH the Queen at the launch of the Information Age gallery, 24th October 2014, with the giant 6 metre high tuning coil from Rugby LW station

Fig.17: One of the display cabinets at the 'Information Age' gallery.

Royal Wootton Bassett Special Auction October 9th 2016

photos by Greg Hewitt

A view from the stage

HMV 900 Pre-War TV - Sold for £8500

Stella Dual Standard TV on stand

HMV 1200 Motion Tuned Radio

Defiant 1935 Receiver

Rogers Ravensbrook Amplifier

British transistor manufacturers in the 1950s

By Stef Niewiadomski

The invention of the transistor in late -1947 by John Bardeen and Walter Brattain at AT&T's Bell Laboratories in the US sparked the beginning of a new age in electronics, and led to the benefits (or drawbacks, whichever way you see it) of the highly-connected Internet period in which we live today. William Shockley contributed to the theoretical understanding of the transistor effect, and almost ten years later, when the ground-breaking significance of their work had been recognised, the three men were awarded the Nobel Prize in Physics, see Figure 1.

Work began immediately in the US on turning the laboratory curiosity into a robust device that could be produced in large numbers, and similar activity started in Europe, particularly in Philips in Holland, and in GEC in the UK. In 1952, Bell Labs took the decision to licence its transistor technology (for the payment of a fee) to other companies – in the US and elsewhere - taking the view that they would themselves benefit from advances made generally in this fledgling industry, and some UK companies took up licenses.

This article details the UK-based companies who 'had a go' at designing and making transistors - and publicised the fact, and some of the applications into which these early transistors were designed. Today, many of the transistors produced are rare historical curiosities, and are collected in the same way that we collect radios, TVs, Hi-Fi amplifiers and so on.

The need for transistors

At the beginning of the 1950s, there was a vast electronics industry in the UK. Some significant sectors were computers; military and civilian aircraft; telecommunications; radar; missiles; military hardware of all types; domestic and professional radio; television; and broadcasting - the list is almost endless. There was even a British space program, started in 1952, using British satellites initially on British, and eventually on American rockets. All of these industries were users of valves on a large scale, and the prospect of a decrease in space and power, and the increased reliability of transistors, created a demand which would lead transistors to start to supplant vacuum technology as the 1950s wore on. It's hard to believe, but the vast majority of the components (active and passive) used in these applications at that time were made in the UK, and it would have seemed natural to continue this situation as semiconductors were developed and entered production.

In the 1940s and 1950s, many mathematical problems were solved using analogue computers, but since the war – when the electronic digital computer had been born – digital computers were seen as the way forward for general purpose computing. Germanium diodes were the first semiconductor devices to make an impact, and in the late - 1940s and early - 1950s, many computers were built using thousands of germanium diodes alongside thousands of valves. Manchester University were pioneers in the design of digital computers (the word 'computor' was often used at the time), initially valve-based, and then using transistors. At the time, the pioneering work at Bletchley Park during the war was unknown, and UK post-war designers were largely starting from scratch with architectures and how to implement them. It's also true that computers like Colossus were designed for a very specific purpose, and were not general purpose 'stored program control' machines, which were needed to be a commercial success.

As well as the logic needed in digital computers, transistors also helped in tackling the tricky subject of program and data storage. There were various technologies (for example, magnetic drums, CRT-based storage systems and mercury delay lines - down which ultrasonic pulses were transmitted) available for what we would call mass-storage, but potentially the most compact and fastest was based on miniature magnetic cores, which were 'stitched' together with the various address and data wires. These cores used high current pulses for writing, and sensitive amplifiers to read their contents, and large numbers of active devices were needed to make them usable. Transistors, with their small sizes and zero heater power, were therefore ideal for the application, and many types were developed for this purpose.

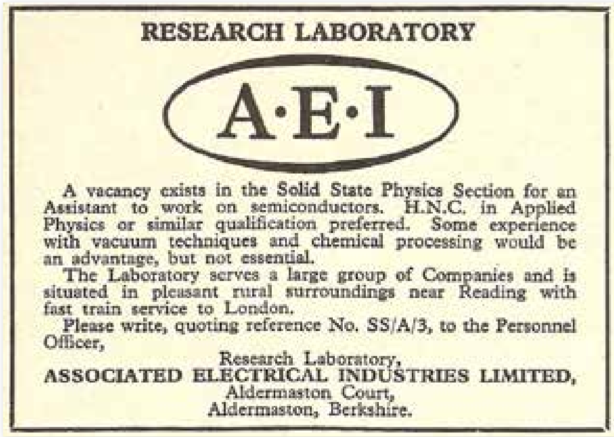
What is generally regarded as the world's first fully-transistorised digital computer – the Experimental Transistor Computer - was built at the University of Manchester in prototype form in November 1953, and in its final form in April 1955. The machine used point-contact transistors, made in small quantities by GEC (the GET2), STC and Mullard's OC51. These early transistors had to be tested one-by-one before being used, and a high proportion failed the tests: at this time, they were certainly not suitable for use in high volume consumer or industrial products.

Many well-known British companies formed their own computer design departments in the 1950s. Among these British companies were: Ferranti with its Argus computer, developed in 1958 for military use, and the transistorised Sirius - 'weighs only 5cwts' - commercial computer (see Figure 2); Leo Computers Ltd (part of J Lyons & Co Ltd - yes, it's the company that owned the tea shops) where the demand for automated payroll and inventory tracking led to the internal development of the LEO (Lyons Electronic Office) range of

Figure 1: John Bardeen, William Shockley and Walter Brattain (left to right), the inventors of the transistor, pictured in Bell Laboratories. They jointly won the 1956 Nobel Prize in Physics for their work in this field.

Figure 2: Sirius, Ferranti's first commercial transistorised computer, developed in 1959, and weighing in at 'only 5cwts'.

Figure 4: The Medresco type OL10 valve-based hearing aid, as featured on the front cover of Practical Wireless for March 1957. The ferrite rod aerial has been added to adapt the hearing aid into a portable radio.



RESEARCH LABORATORY

A·E·I

A vacancy exists in the Solid State Physics Section for an Assistant to work on semiconductors. H.N.C. in Applied Physics or similar qualification preferred. Some experience with vacuum techniques and chemical processing would be an advantage, but not essential.

The Laboratory serves a large group of Companies and is situated in pleasant rural surroundings near Reading with fast train service to London.

Please write, quoting reference No. SS/A/3, to the Personnel Officer,

Research Laboratory,
ASSOCIATED ELECTRICAL INDUSTRIES LIMITED,
Aldermaston Court,
Aldermaston, Berkshire.

Figure 5: 1957 advert for an assistant engineer to work in semiconductors at AEI's Research Laboratory in Aldermaston.

LEO COMPUTERS LTD.
TRAINING TO BE
COMPUTER ENGINEERS

Young men with G.C.E. " A " in Physics and Mathematics (or equivalent), without engineering experience, are offered

OPPORTUNITY TO TRAIN AS
ELECTRONIC COMPUTER
ENGINEERS

This is an excellent opportunity for anyone who has completed National Service (or will do so during 1957) to train from scratch to reach positions of responsibility in this rapidly expanding field. Applicants should write, giving personal and educational details, and an outline of any experience to:

The Personnel Officer,
Leo Computers Ltd.,
Elms House, Brook Green,
London, W.6.

Figure 6: Leo Computers Ltd's 1957 advert for computer engineers - note the emphasis on only men needing to apply.

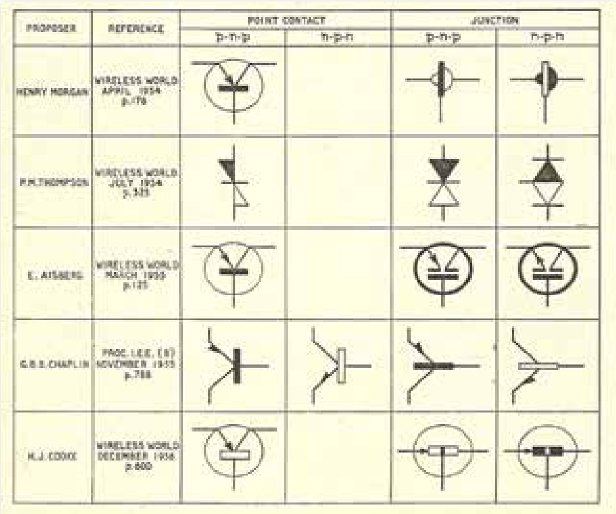


Figure 7: Summary of some transistor symbols suggested by Wireless World correspondents over just a couple of years. The blobs on the envelopes normally used by the magazine have been deliberately omitted.

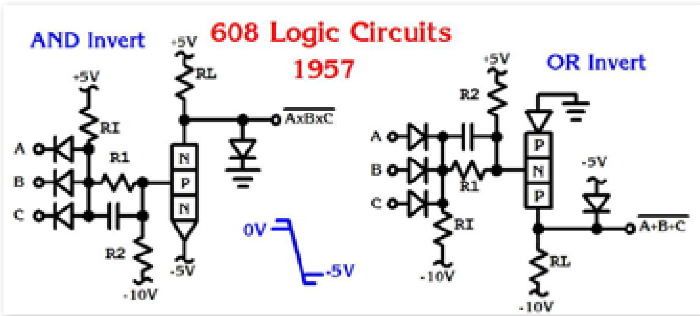


Figure 8: IBM's representation of diode-transistor logic (DTL) in its 1957 model 608 computer.

computers (of which LEO III was based on transistors) until its merger into English Electric, then ICL, and ultimately Fujitsu; English Electric, with its DEUCE machine and later KDF range, which led to the very successful transistorised KDF9; EMI with its Emidec 1100 (using Mullard, STC, GEC and even some RCA transistors) – one of which it supplied to British European Airways for £250,000 in 1959; Metropolitan-Vickers, with the 950 (using STC TP1 and TP2 point contact transistors), a commercialised version of the Manchester University 1955-vintage computer; the Atomic Energy Research Laboratory at Harwell with its CADET computer (using very early point contact transistors from STC); and Elliott Brothers 800-series computers (from 1957 onwards) which were transistor-based.

See Reference 1 for more on-line details of these British computers, specifically those using transistors. References 2, 3 and 4 are very interesting and informative accounts of early computer developments in the UK, including the gestation, pioneering work and eventual demise of Leo Computers Ltd, and the use of computers in the British Army.

Transistor applications

Another potentially high volume user of transistors was in the relay market. In 1957, Magnetic Devices Ltd (based in Newmarket, presumably not too far from Newmarket Ltd's transistor factory) advertised the first transistorised relay, the hermetically sealed 595HS. The relay could be controlled by a mere 0.4mA at 2V, and its contacts could handle 5A at 230V AC.

From 1957 onwards, Multitone marketed a transistor-based paging system for use in hospitals and commercial buildings. From a central control unit, a carrier of a small transistorised pocket receiver could be 'buzzed' via a loop of wire surrounding the building, and spoken to if necessary. Although they would turn out to be non-ideal in the front end of radios, transistors were finding their way into communications receivers. For example, as early as 1957, Brooks and Gatehouse (of Lymington, Hants) brought out their 'Homer' TRF radio for use in small sea-going craft.

Test gear was a popular application for the use of transistors. In 1957, Ferguson produced a TV IF wobbulator, using a Philco (see later for Philco's connection in the UK) high frequency transistor for the RF oscillator stage, and Mullard OC-series transistors in the other stages.

As the 1950s wore on, more and more transistor radios – often in kit form – appeared in the amateur press. Figure 3 (Page 21) shows the range offered by Radio Exchange Co, Bedford, in 1959, in the form of kits using one, two, three, and four transistors. This was typical of other vendors, and some offered a full six or seven transistor superhet design, built on a PCB.

Valve-based radio control of models was a popular hobby, almost from the beginning of radio. The advent of transistors solved many of the problems of weight and power restrictions – especially in the models being controlled - and many transistorised systems appeared in the amateur press when transistors started to become available.

Hearing aids

One early application for transistors was in hearing aids. 1950s hearing aids used valves and although they were at the limit of miniaturisation for the time, were still rather big and obvious when worn. Figure 4 shows a Medresco type OL10, as featured on the front cover of Practical Wireless for March 1957. The magazine's article was describing a conversion of the OL10 into a radio, by the addition of a ferrite rod aerial (you can see this in the photo, and it is not part of the original hearing aid), a tuning mechanism and a crystal diode – hence a simple crystal set – followed by the original audio amplification

Figure 9: Brimar's first commercial range of 'good' transistors, as advertised in the August 1956 issue of Radio Constructor.

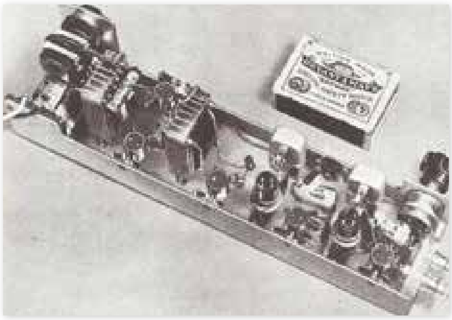


Figure 10: A photo of GEC's 'LS crystal valve receiver – an experimental set using germanium triodes'. The novel TRF design was first shown publicly in 1951.

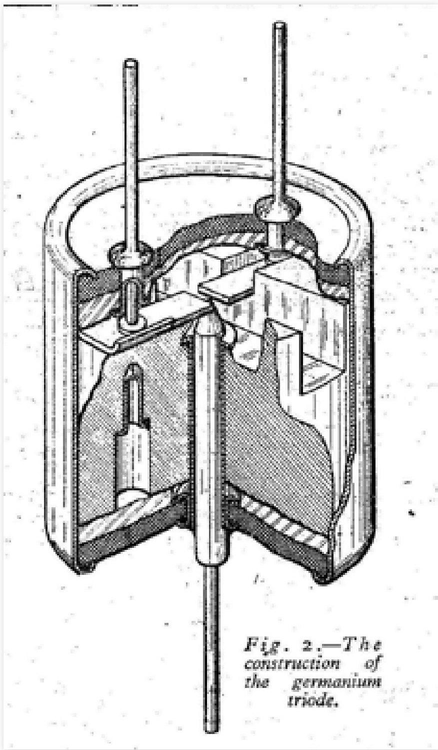


Figure 11: A cut-away diagram of the point contact devices used in the GEC LS crystal valve receiver.

stages. The hearing aid used three miniature valves (two DF71s and a DL70), and the photo shows in the user's right hand the HT and LT batteries it needed, and which needed to be accommodated in a pocket. I leave it to your imagination what the consequences of leaking batteries could be. In 1958 the company brought out its first transistor model, the OL58, which was adopted by the National Health Service, and whose much smaller batteries made the device very much easier to wear.

See Reference 5 for a link to the Hearing Aid Museum, a fascinating history of this technology, including valve and transistor based devices.

Job adverts

One way of measuring the progress of transistor technology is by looking at the job adverts in the professional magazines which mention semiconductors. Wireless World had a professional (and amateur) readership and so is a good starting point, and there are still lots of these magazines around. It's probably in about 1957 that transistors started to get a mention in job adverts, and then only very occasionally.

Browsing through some 1957 issues, I can see Murphy Radio Ltd Electronics Division, as well as their domestic radio design laboratory, asking for expertise in transistors, as are Venner Electronics Ltd. Amongst the semiconductor manufacturers, Texas Instruments Ltd in Bedford, and AEI's Research Laboratory (see Figure 5) - who conducted much basic research into semiconductors, and sold it on to transistor and diode manufacturers, as well as providing pure crystals of germanium and silicon - in Aldermaston, were recruiting for engineers to work in the field.

In the lead up to the great proliferation in computing, Leo Computers Ltd was looking for computer engineers (see Figure 6). It's not clear exactly what these engineers were expected to do: in those pre-operating system days I suspect it was to become 'computer operators', who loaded program and data tapes into computers to initiate batch programs, such as payroll calculations. There may have been a servicing aspect to the job, that is, the ability to spot faults with the machine and change boards to fix them. Leo Ltd was also recruiting computer designers: in 1957 their machines were valve-based and their first transistorised computer appeared in 1961, and so the late 1950s must have been a period of great innovation in the company.

Transistor symbols

It took a while for the symbol for the transistor to be standardised, and a debate took place in the pages of Wireless World on suggestions for the symbol(s) to be used. Figure 7 shows a summary of those suggested over just a couple of years. Note that some contributors wanted the symbol used to differentiate between point contact and junction transistors. Contributors who did not really understand the new technology saw the future evolution of semiconductors through eyes used to valve technology, and foresaw the need for tetrode, pentode and so on, transistor symbols. I guess they were almost right, in that dual-gate MOSFETs (almost like a tetrode), and multi-emitter transistors (pentodes, etc) were developed, though they are not analogous to valves with a similar number of terminals.

Meanwhile transistor manufacturers and users adopted their own styles: certainly IBM (see below) made up its own symbol when it represented a DTL (Diode Transistor Logic) 'gate'. There have been various British (for example BS 3939) and international standards for transistor symbols (and other electronics components, of course) over the years. I recall in the 1970s when schematic CAD systems were first being used and the symbols used for such simple components as resistors had to be modified because the plotters couldn't draw zig-zag lines.

Figure 8 shows how IBM represented DTL in its 1957 model 608 computer: note the use of PNP and NPN transistors, and IBM's own symbol for the transistors. DTL has the advantage that layers of logic can be cascaded and a logical inversion is easy to implement, unlike the simpler resistor-diode logic (RDL) where voltage levels are degraded as logic is cascaded, and only AND / OR functions can be built. Some early computers did not use conventional logic, but used instead small transformers which combined pulses amplified by the transistors.

Of course the FET and the MOSFET would acquire unique symbols of their own, reflecting the fact that the gate (equivalent to the base in a bipolar transistor) was electrically insulated from the source-drain channel.

Components for use with transistors

The adoption of the transistor drove great innovation in the design of new components, which enabled designers to use transistors at all. For example, new RF coils, IF and audio transformers, miniature electrolytic capacitors (there was great innovation here by the likes of Plessey), tuning and trimmer capacitors,

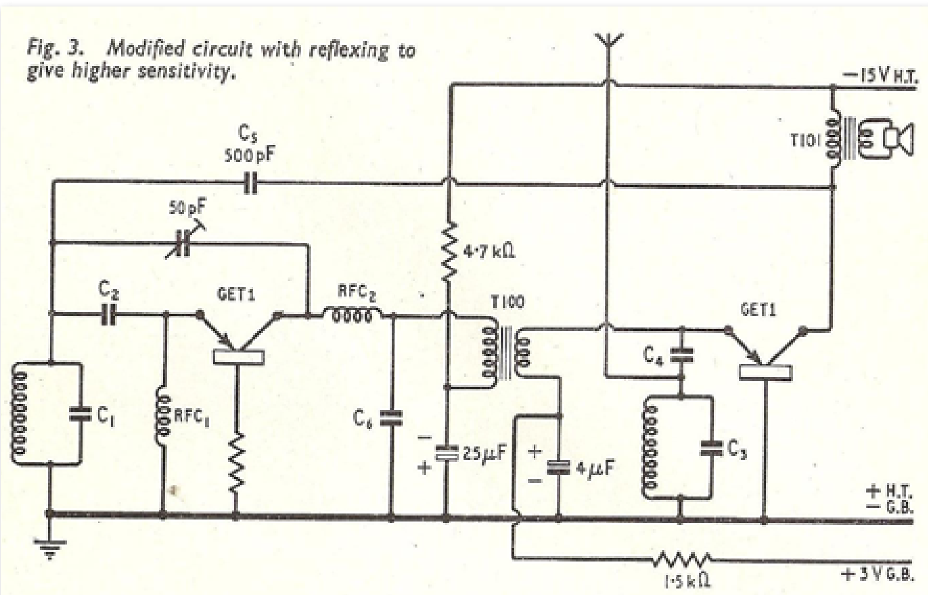


Figure 12: The reflexed version of B R Bettridge's two transistor radio, published in the January 1954 issue of Wireless World. A simpler non-reflexed version was also shown in the article.

potentiometers, and batteries (Ever Ready, for example, with the introduction of the PP1, PP6, PP7 and PP9, and Mallory with its miniature batteries) were developed. Denco, Repanco, Osmor and others redesigned their ranges of valve coils to match the different input and output impedances needed, and miniaturised the coils so that designers could take advantage of the small size of transistors, and mount them on PCBs.

Although PCBs had already been used for valve circuits, it was in the early transistors era that they became an almost essential method for mounting transistor circuits efficiently, and eventually resulted in highly automated ways of assembling electronic units.

Types of transistors

The transistors made initially in the Bell Labs in 1947 were PNP bipolar double-point contact germanium devices. From a mechanical point of view these transistors were severely limited by the fragility of the metal (gold foil was used) contact to the germanium crystal, and the variability of the quality and spacing of the metal to semiconductor junctions, which were placed manually onto the base germanium. At the time, the inventors were experimenting with surface phenomena on the germanium crystal and the useful properties they saw may have been more to do with surface effects than the bulk effects normally associated with the bipolar junction transistor.

William Shockley saw the limitations of the point contact transistor very early on, and realised that they would prevent transistors from ever being globally accepted. Once the point contact transistor had demonstrated that the concept of the transistor worked, he began development of a diffused junction structure, which had the potential for making much more reliable devices.

In one implementation of this type of transistor, the emitter and collector started life typically as blobs of indium carefully placed on the base germanium crystal, The crystal was then heated in a controlled way until the indium melted into the germanium, leaving a thin n-type base region sandwiched between the emitter and collector p-type regions, to which reliable metallic contacts could be made. This basic process was adapted by manufacturers to make the various types of transistor they wanted to sell, and much selection was used at the end of the production line to sort the devices into AF, IF, RF, etc 'bins' for final testing and marking.

Other ways of producing transistors with reliable and predictable junctions were developed, and there are many references on the Internet to these techniques, if you want to learn more. It's very useful, for example, if the collector is formed as a major part of the bulk material, as this can be efficiently heatsinked, and high power dissipation achieved. The first silicon transistor was made in the US in 1954, and this element was much trickier to process than germanium, which remained dominant throughout the 1950s.

Transistors in space

The transistor's reputation for high reliability and low power took a massive step forward when the US launched Explorer 1, its first satellite to reach orbit, on 31 January 1958. It had been beaten into space by two previous

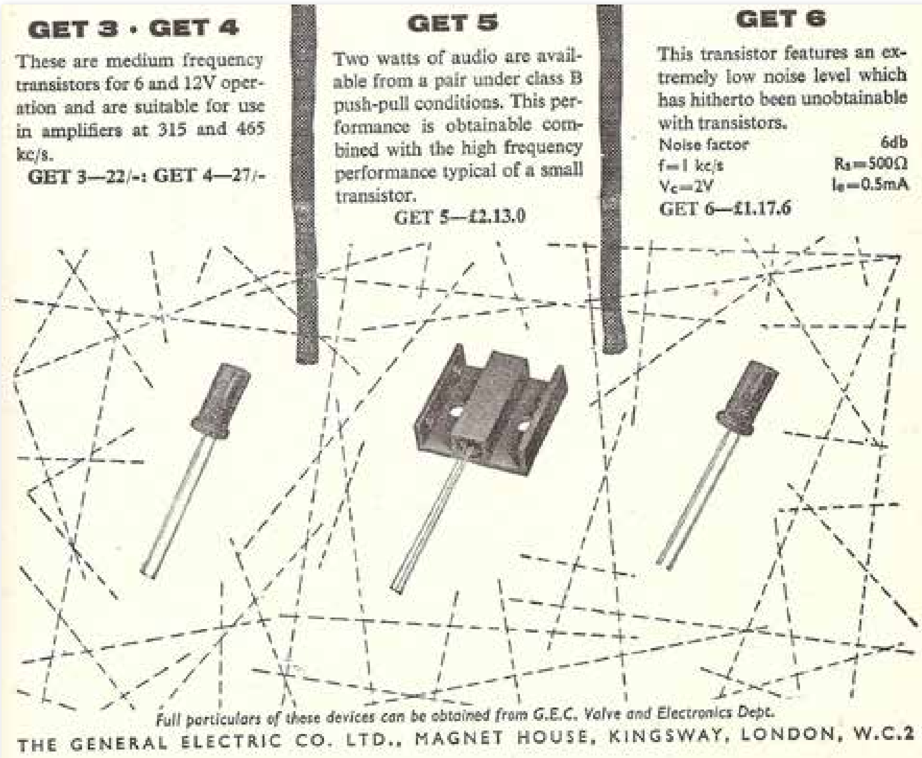


Figure 13: GEC's 1956 range of transistors.

Figure 14: A Pye V10/50B and a pair of Mullard OC72s (in heatsinks) in my Pye P123BQ radio.

Soviet launches, but the transmitters on board the Sputniks were probably valve-based (there are some suggestions that a few Russian transistors were used in Sputnik, but this would be very difficult to confirm today) permitted by the much greater lifting power of the Russian rockets, which allowed heavier batteries to be carried.

Explorer 1 carried two transmitters, one using a single Western Electric WE-53233 transistor and transmitting on 108.03MHz, and the other a WE-45011 device transmitting on 108.00MHz. These two transistors were PNP diffused base germanium types. In all, there were 29 transistors in Explorer 1, doing various data gathering and control functions. In the UK, transistors were certainly being used in the ground-based elements of missile systems, and may well have been used in the missiles themselves by this time.

See Reference 6 for a very readable and informative account of the use of transistors in Explorer 1 and subsequent American space launches.

Now that the invention and structure of the first transistor have been (briefly) described, and the need for transistors has been established, I'll move on to detailing the most significant British manufacturers who embraced the technology.

Associated Electrical Industries Ltd (AEI)

AEI's Research Laboratory in Aldermaston performed ground-breaking research into transistor technology in the 1950s. The AEI mother company owned many subsidiaries, including several companies who manufactured diodes and transistors in the 1950s, and so the influence of AEI's research was probably more significant than is obvious, though internal communication was said to be poor, and internal competition and inefficiency were rife. AEI owned Siemens Edison Swan Ltd; British Thompson Houston (BTH); and Metropolitan-Vickers. See later in this article for the contributions of these companies to transistor production. For a brief time, 'AEI Semiconductors Ltd' (based in Lincoln) existed, and after a chaotic time for the whole AEI group in the first half of the 1960s, the company was bought in its entirety by GEC in 1967.

Standard Telephones and Cables Ltd (STC) / Brimar

Brimar was a well-known British manufacturer of valves, generally with US-type codes, and had post-war experience with germanium-based power rectifiers. The first transistors that Brimar made and offered commercially were coded 3X/ followed by a serial number. For example, the 3X/301N and the 3X/302N were used in 'A Transistor Diode Portable' published in Practical Wireless for August 1956, though there were earlier 3X-coded transistors before these. There were also some 2X-coded germanium diodes, and so Brimar used the first digit to indicate how many terminals the device possessed.

The first transistors seriously intended for commercial applications were coded TP1, TP2, TJ1, TJ2, TJ3, TS1 (which seems to have been the 3X/301N), TS2 (was the 3X/302N) and TS3 (see Figure 9), the bodies of which were about 1-inch long. The second letter of the code seems to have been more of a way of indicating the package style, rather than the underlying transistor technology: although both the TP devices were 'point contact n-type' (that is, PNP) devices. The TP1 was designed to run at up to 100kHz in control and switching applications, and although this seems to be painfully slow today, was not untypical of the speed of early transistor-based computers. The TS1, TS2 and TS3 were of PNP alloyed junction construction, as were the TJ1, TJ2 and TJ3, but with a maximum collector dissipation of 200mW.

From about 1959, Brimar offered a range of transistors with codes starting with 'TK', and most of the previous devices were obsolete by then. For example, the TK25A was the highest frequency device (8MHz, for use in RF applications); the TK40A (1.5MHz) was intended for use in IF amplifiers; and a number of TK-coded devices for use in LF/AF circuits. Though beyond the scope of this article, Brimar continued to produce germanium and silicon transistors throughout the 1960s and 1970s (and beyond?), and built a very successful semiconductor business.

Designs using early Brimar transistors in the amateur press are tricky to find. A notable design was the three-transistor medium wave 'Transistorette' radio published in The Radio Constructor in 1956 (see Reference 7). A ferrite rod aerial (supplied by Osmor) fed a Brimar GD3 germanium diode, and the resulting audio was amplified initially by two TJ2 transistors, and the class A audio output stage - a TJ3 or TS3, needed for their higher dissipation – drove a loudspeaker. So the design was essentially an amplified crystal set, with no need for RF-capable transistors.

Figure 20: Production line workers at Mullard's Southampton factory attaching leads to the emitter and collector pellets of early diffusion transistors.

The General Electric Co Ltd (GEC)

Before 1946 the only source of germanium was from the US, recovered as a by-product from the production of zinc and cadmium. GEC led the way just after the war in the production of a local source of germanium, much of it derived from the flue dust collected from coal-burning gas production plants in the UK, for use in power rectifiers. Therefore GEC had experience in the properties of the element, and in how to refine it into very pure crystalline form.

In November 1951 Wireless World featured GEC's 'LS crystal valve receiver – an experimental set using germanium triodes'. Note that at this early stage, the word 'transistor' was not being used. The novel TRF design (see Figure 10) used five germanium 'triodes' (see Figure 11 for a cut-away diagram of these devices) and was capable of driving a loudspeaker (hence LS in the title) via a push-pull audio output stage. The radio was powered from a 50V source, presumably with lots of taps to provide the various voltages for the transistors. The diagram shows the internal structure of the transistor: the emitter and collector connections were made to the two leads exiting from the top of the case, which were connected to phosphor-bronze strips which had been sheared from a single strip, cut with a gap of a few thousandths of an inch. The germanium crystal was soldered to the tip of the bottom lead (which became the base terminal), ground to a point, and the resulting cone was pushed into the gap between the strips. What resulted was a metal-semiconductor transistor – no mention was made in the article of 'forming' the collector or emitter, but of course GEC may not have given away all their secrets.

The September 1953 issue of the Radio Constructor mentioned a similar-looking transistor, which by now was called the GET1. GEC announced that the transistor was now in pilot plant production, and was available 'to equipment makers in sufficient quantities for experimental work and prototype equipment'. The GET1 was mentioned again in the June 1954 issue of Wireless World: B R Bettridge, who worked at GEC's Osram Valve and Electronic Department (see also Reference 8), published a two-transistor receiver design. In fact he published two designs: one was a simple two stage radio, with reaction applied to the RF stage, and the second (shown here in Figure 12) used reflexing to effectively double the number of stages. This technique was very common in the early days when transistors were expensive, and a single device could be used for RF amplification, and then the recovered audio would be fed back into the RF stage for AF amplification.

Henry Irwin described his brave attempt to reproduce the Bettridge design in the winter 2005 issue of the BVWS Bulletin, building his design into a clear Perspex case, as used for the original radio. The GET1 transistors were impossible to source and so he used Western Electric 2N110s (which had 1956 manufacturing codes) which are of point contact construction, and can still be purchased from specialists who deal in vintage components. Henry made a working radio, but it proved to be more difficult than anticipated,

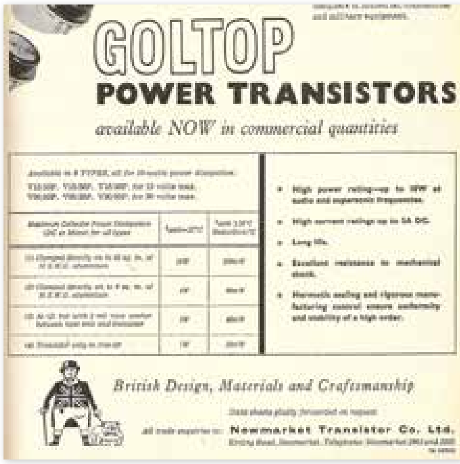


Figure 15: Newmarket Transistor Co Ltd's Goltop-branded range of transistors in 1957

EQUIVALENTS FOR DISCONTINUED EDISWAN RANGE

EDISWAN	BRITISH EQUIVALENT (Approximate)	AMERICAN EQUIVALENT (Exact)
XA101	OC45	—
XA102	OC44	—
XA111	GET873	—
XA112	GET874	—
XA131	—	2N384
XA141	—	2N643
XA142	—	2N644
XA143	—	2N645
XA151	GET871	—
XA152	GET872	—
XA161	2N711	2N1300
XA162	—	2N1301
XA701	—	2N585
XA702	—	2N1090
XA703	—	2N1091
XB103	OC71	—
XB104	OC70	—
XB112	GET103	—
XB113	GET113	—
XB121	—	2N398
XC101	OC72	—
XC121	GET103	—
XC141	GET572	2N301
XC142	—	2N301/A
XC703	—	2N1479
XC713	—	2N1483
XC723	—	2N1487

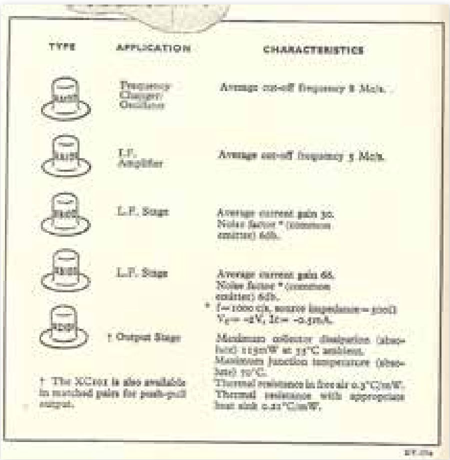
Figure 17: Table showing equivalents to Ediswan transistors. Note how the compiler of the list has differentiated between approximate and exact equivalents.

and it exhibited an interesting warm-up effect. The article is well worth reading to make you realise how hit-and-miss the process of designing with these early transistor was.

The point contact transistor lived on, perhaps for longer than it should have: in 1955, GEC announced the EW51, a 'high frequency' point contact germanium device designed for use in pulse circuits, and clearly aimed at the computer market. The design of the transistor seems to have minimised 'bottoming' – which today we would call 'saturation' – whereby a further increase in the value of the input signal causes no further change in the output signal, but has a detrimental effect when the input changes state and the saturation current has to be dissipated before the output can start to change state, hence slowing down the switching action.

By 1956 the GET1 (and the GET2) had disappeared, and GEC announced a new range of transistors (see Figure 13) consisting of the GET3, GET4, GET5 (formerly the EW70) and GET6 (derived from the earlier EW57). Note how the company has included prices for the devices on the advert. A year later, the GET7-GET9 power transistors, in what looked rather like a TO3 package, were released.

The GET5 design incorporated a neat



TYPE	APPLICATION	CHARACTERISTICS
	Frequency Changer/ Oscillator	Average cut-off frequency 8 Mc/s.
	I.F. Amplifier	Average cut-off frequency 5 Mc/s.
	L.F. Stage	Average current gain 30. Noise factor * (common emitter) 6db.
	L.F. Stage	Average current gain 66. Noise factor * (common emitter) 6db. * f=1000 c/s, source impedance=500Ω V_c=-2V, Ic=-0.5mA.
	† Output Stage	Maximum collector dissipation (absolute) 115mW at 35°C ambient. Maximum junction temperature (absolute) 70°C. Thermal resistance in free air 0.3°C/mW. Thermal resistance with appropriate heat sink 0.21°C/mW.

† The XC101 is also available in matched pairs for push-pull output.

Figure 16: The five Ediswan transistor types available in mid-1957.

Figure 18: Mullard's January 1954 announcement that the company's transistors were now in a state to be designed into end-equipment.

anodised heatsink, about one inch square. It was reported that 'all these transistors have been in pilot production for about two years, and should be in quantity production later this year' – which goes to show just how long it took to iron out design and production issues. These transistors looked more like what we now expect, with all three leads leaving the package at the same end. Although not explicitly stated at the time, I presume these transistors were of the diffused junction type.

The GET3 was reliable enough to find itself in the audio stages of GEC's first transistor radio, the BC1650, released in 1957. Clearly GEC could not yet make frequency changer / IF amplifier transistors, and Ediswan XA-series devices were used. Disappointingly for GEC's transistor arm, their next portable radio, the BC501 – released in May 1959 - used an all-Ediswan transistor line-up, and they were only thrown a scrap in the form of a GEX34 diode. Some later radios, including the BC505, did use GEC transistors, though Ediswan and Mullard devices tended to take precedence in most transistor-based GEC radios.

GEC pioneered the use of transistors in TVs: in 1957, at the Television Society exhibition, they demonstrated an experimental set (see Reference 9) in which the line and frame timebase oscillators, as well as the respective sync separators, were transistorised. A power transistor was also used in the frame output stage. The transistors used were unspecified 'experimental' types, including a germanium NPN device, which was novel for the time.

In 1958, GEC renumbered its transistor range to GET plus three digits, giving us the GET113, GET114 and so on. The GET871-GET874 formed a range of IF/RF transistors, which were also good for high speed switching, and found their way into some contemporary computers.

The BC562, GEC's first transistorised AM/FM radio, released in August 1960, used GET113s and GET114s, and devices coded T1832, T1833 in the RF stages, and T1657s in the 10.7MHz IF stages. These 'T' coded devices were sourced from Philco, perhaps via Semiconductors Ltd (see later).

Newmarket Transistors Ltd (Pye, Goltop)

Newmarket Transistors Ltd was a wholly owned subsidiary of Pye Ltd, tasked with manufacturing transistors to supply Pye's internal radio business. Pye had not previously manufactured valves, and so this represented a new foray into active devices for the company. These transistors were used in the UK's first production transistor radio, the Pam model 710, released in 1956. Pam was also a subsidiary of Pye, used so that the Pye brand would not be tainted if the radio turned out to be a failure. The 710 used a V6/R3M and a V6/R3 in separate local oscillator and mixer stages; a V6/R3 and a V6/R2 as externally neutralised IF amplifiers at 315kHz (to reduce the frequency at which the local oscillator had to run); a V6/R2 as a 'collector-bend' detector; and three V10/30As in the audio driver and output stages. It may be that a rather expensive V6/R2 was used as the detector because the company never produced any diodes - sticking to its literal name - and it didn't want to use another manufacturer's device in its radio.

In fact the Pam 710 radio was a great success, and Pye used its own branding on the UK's second commercial transistor radio, the P123BQ, released in early 1957. By now the local oscillator and mixer had been merged into a single stage, saving one expensive transistor, and the detector stage used an OA70 germanium diode, saving one more transistor. I have a P123BQ and Figure 14 shows a few of the transistors used in my radio: as you can see, a mixture of Pye and Mullard transistors are used. The Pye transistor line-up was similar to the Pam 710, but service sheets for the radio suggested that the Mullard OC71 and OC72 were alternatives in the audio stages – Mullard were clearly making their presence known and perhaps this hints at Pye's semiconductor factory not being able to keep up with demand, and at low enough prices to compete with Mullard. Later versions of the P123BQ show that eventually the Pye transistors improved enough to enable the IF to be raised to the conventional 470kHz.

The company later re-numbered its consumer transistors as white circle, yellow circle and green circle followed by a digit 1 (frequency changer), 2 (first IF amplifier), 3 (second IF amplifier), 4 (AF amplifier) or 5 (AF output stage). These transistors were used in the Pye Q1, Q3, Q4, etc series of portable radios, though some of the later models had the option of using Mullard and/or NKT-numbered transistors.

In 1957, the company started to offer a range of power transistors (still PNP germanium), branded 'Goltop' – which I take to be an abbreviation of 'Gold Top'. Figure 15 shows the range of six transistors in production, with 15V or 30V maximum working voltage.

You may be more familiar with Newmarket's part numbers beginning with 'NKT', and I believe this superseded the 'V' and 'circle' series in about 1961.

English Electric Valve Company

The English Electric Valve Company was a minor player in the British transistor industry, and is said to have made only three transistor types, with codes starting with 'VB', in the 1950s. These may have been in English Electric's early experiments with transistorised digital computers. In 1960, its transistor arm was merged into Associated Transistors, a joint venture between Ericsson Telephones, Automatic Telephone and Electric Company (these two companies became Plessey Telecommunications in 1961) and English Electric, and was eventually acquired by Mullard in 1962.

Ediswan - Siemens Edison Swan Ltd

The company's Ediswan-branded 'top hat' transistors are distinctive, and a range of five germanium PNP junction transistors were released in 1956. As far as I can tell, they did not commercially release any point contact transistors. Ediswan seems to have been on par with Mullard at this point, as the XA102 frequency changer / local oscillator was similar to the OC44, and the XA101 IF amplifier was similar to the OC45. A mid-1957 advert (see Figure 16) shows these five Ediswan types, and the company was able to announce the availability of 'a complete range of transistors for radio and electronic applications'.

These early Ediswan transistors were fairly successful, and found their way into many early British transistor radios, sometimes specified as a 'second source' to Mullard devices. For example, they were used in Ever Ready's Sky Prince and Sky Personal portables.

In 1959 the company released two new audio output transistors – the XC121 and the XC131. The case style was rather more

Figure 19: A Mullard OC45 soldered into the chassis-mounted insulated bushes in a 1959 Bush TR82 portable. The '3N2' code may well be an indication of the manufacturing date and/or location.

	TYPE	DESCRIPTION	RISE TIME millimicroseconds	Vc max	Ic max
HIGH-SPEED LOW-LEVEL SWITCHING **GERMANIUM**	SB 344 SB 345	General purpose transistors for conventional logic circuits.	50	5v	5mA
	SB 240	Designed for directly coupled circuits. Controlled input, saturation and hole storage characteristics.	30	6v	15mA
	MA 393	High gain transistor for high-speed driving of parallel circuits.	30	6v	50mA
	2N 501	Ultra-high speed transistor with controlled input and saturation characteristics.	10	12v	50mA
HIGH-SPEED LOW-LEVEL SWITCHING **SILICON**	SA 495	General purpose 10Mc/s transistor for conventional logic circuits.	100	25v	50mA
	SA 496	15Mc/s transistor for directly coupled circuits. Saturation resistance typically 10 ohms. Controlled input and hole storage characteristics.	80	10v	50mA
CORE DRIVING **GERMANIUM**	2 N 597 2 N 598 2 N 599	min $f\alpha$ 3Mc/s min $f\alpha$ 5Mc/s min $f\alpha$ 12Mc/s — 250 mW high frequency alloy transistors with high gain and low saturation resistance	400 * 250 * 100 *	20v 20v 20v	400mA 400mA 400mA
	2 N 600 2 N 601	min $f\alpha$ 5Mc/s min $f\alpha$ 12Mc/s — 750 mW versions of 2 N 598 and 2 N 599. Peak current 3 amps.	250 * 100 *	20v 20v	400mA 400mA

* rise time to 400mA

Figure 21: The broad range of germanium and silicon transistors offered by Swindon-based Semiconductors Ltd in 1959. Most of these transistors were manufactured by Philco in the US.

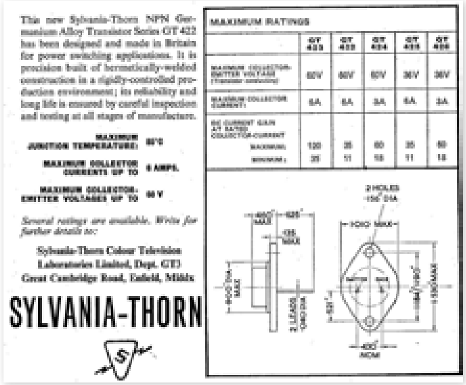


Figure 22: Sylvania-Thorn's November 1959 advert in Wireless World, showing its range of UK-produced NPN power transistors.

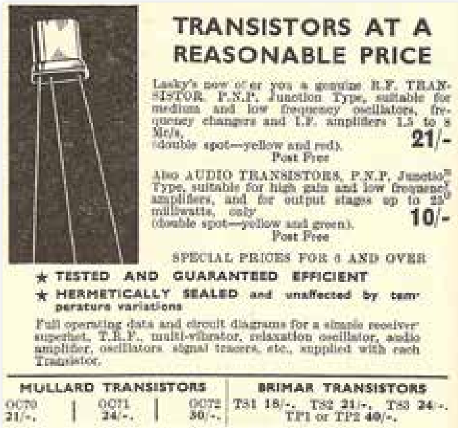


Figure 23: Lasky's June 1957 advert for unbranded 'spot' transistors, and branded devices from Mullard and Brimar.

conventional (new transistors were being offered in this alternative case style from the end of 1958), and the XC131 was in fact two matched transistors complete with a heat sink for use in class B audio output stages. I've also seen reference to an XC171 (in the Sky Prince), a pair of transistors similar to the XC131. By advertising transistors at reasonable prices, amateurs were encouraged to use the company's transistors, and they found their way into many articles in the amateur magazines.

Also in 1959, the company changed its official name from 'Ediswan Mazda Valve and CRT Division' to 'Ediswan Mazda Valve, CRT and Semiconductor Division', presumably reflecting the fact that transistors were making a significant contribution to the business, and that the company were in the semiconductors business for the long term. A restructuring took place in 1960, when Siemens Edison Swan Ltd became part of AEI Radio and Electronic Components Division. The Ediswan Mazda branding continued to be used for a while, until the company was absorbed into GEC in 1967.

Figure 24: My 'red spot' transistor, bought in the 1960s, and still working.

With an eye on the computer / industrial control markets, a small range of switching transistors was released in 1959, including the XA151 and XA152, and more were introduced in the early 1960s.

Figure 17 shows an interesting table (taken from Reference 10) showing equivalents to Ediswan transistors. Note how the compiler of the list has differentiated between approximate and exact equivalents. We already know that the OC44 was similar to the XA101, but why is the 2N384 exactly equivalent to the XA131 - a germanium PNP drift device, capable of operating at VHF. The answer lies in the fact that some XA131s have been seen with 'Made in USA' stamped on them. The company had obviously signed a deal with a US transistor manufacturer (or more than one) for the supply of transistors they were unable to make, which they re-marked with Ediswan codes, and sold in the UK, and perhaps elsewhere in Europe. This was not an unusual practise at the time (for example, see later in the Semiconductors Ltd section) and had been used for valves for many years.

Mullard Ltd

Philips made an early decision to get into transistor research and manufacture in Holland, and in 1949 made their first point contact transistor, emulating the Bell achievement. In 1951, semiconductor research and manufacture was 'spun off' into a separate group and a new factory, specifically for the production of diodes and transistors in Eindhoven, was built. To accelerate the rate of research, a license from Bell was taken up. Transistor research was started in the UK, initially in Mitcham, and from 1957 onwards in a purpose-built factory in Southampton. As well as being a transistor (and diode) factory, this location was fully equipped with research, development and applications departments. The OC-series of germanium transistors, and the OA-series of diodes, are Mullard's best-known devices of the early years.

The first Mullard-produced transistors were the point-contact OC50 and OC51, manufactured from 1952 onwards for use in hearing aids, followed by the OC10, OC11 and OC12 intended for use in low power audio amplifiers. The plastic encapsulation used on these early transistors turned out to be porous, and moisture ingress ruined them after a short while, and the devices were soon obsoleted. The later OC57-OC60 range fixed the encapsulation problem, and being very small, was again targeted at hearing aids.

Some OC50s fell into the hands of radio amateurs, and G3IEE built and operated a single transistor 160m (1.8MHz) CW transmitter, and G3CMH built an 80m (3.5MHz) transmitter, in 1954. They achieved the earliest transistorised amateur-to-amateur contacts in the UK, in the case of G3CMH over a distance of 90 miles, with an input power to the transistor of about 30mW. G3IEE's circuit was identical to the one that appeared in the May 1953 issue of Wireless World, which described the use of early RCA transistors in a 2m (144MHz) CW transmitter by K2AH. The operating frequency was impressive, and chosen firstly because of the 'exceptionally good aerial' available at K2AH's shack, and secondly because the engineers at RCA were able to 'tweak' the processing and produce these exceptional transistors.

A big step forward by Mullard was the development of glass encapsulation, and this formed the basis of production for several years. Production in Southampton started with the OC44 and OC45 (suitable for use in radio frequency changers and IF amplifiers), the OC71 and OC72 (for audio use) and various diodes. The OC44, OC45 and OC71 were black-painted rounded-top glass tubes, whereas the OC72 (and later audio power devices such as the OC81D and OC81) had a metal tube slipped over the glass to increase power dissipation and allow the connection of a heat sink.

In the January 1954 issue of Wireless World, Mullard advertised under the banner 'The practical application of transistors', and wrote: 'Designers of equipment who wish to experiment with these new transistors are invited to apply now for samples and data'. I think this is a significant step in Mullard's history in the transistor period, and so I have reproduced the announcement in Figure 18.

It had been shown that semiconductor junctions were light-sensitive, and Mullard exploited this effect with the release of the OCP71 phototransistor in 1956. Legend has it that the OCP71was simply an unpainted OC71, and the same function could be obtained by scraping the black paint from the glass case of a less expensive OC71. This seems not to be true: the OC71 was filled with an aluminium oxide and silicon oil mix, which conducted heat away from the junctions, and was light-proof. OCP71s were filled with a clear silicon grease to allow the light through to the junctions. It may have been that a 'scraped' OC71 was to some extent light-sensitive, but it would not have worked as well as a 'real' OCP71.

The UK's first true power transistor, the stud-mounted OC16 was released in about 1956, and quickly found use in audio PA amplifiers and as the class A output stage in hybrid car radios. This awkward case style was eventually abandoned, and the TO3 style we are still familiar with was introduced in the early 1960s, with the OC19.

For use in digital computers, and industrial control systems, there was a demand for switching transistors, and so the OC41 and OC42 were produced. All of the above transistors were PNP, but Mullard also developed the NPN (still germanium) OC139 and OC140 switching devices in 1959.

Mullard captured the transistor market of most British portable radio manufacturers very quickly. In case you've never had the pleasure of seeing one of Mullard's black-painted glass-tubed transistors, Figure 19 shows an OC45 soldered into the chassis-mounted insulated bushes in a 1959 Bush TR82 portable.

For a while the upper frequency limit of Mullard's transistors stuck at about 10MHz, that is OC44-type devices. The development of so-called alloy-drift transistors in 1959 gave us the OC170 and OC171, capable of working at more than 50MHz, and the AF114-AF117 devices a couple of years later. Little did the designers at Mullard realise that the TO7 package, with its outer case acting as a metal shield, would give present-day radio restorers nightmares when tin whiskers grew out from the inside walls and shorted the other terminals to the grounded cases.

It's difficult to untangle exactly where inside Mullard specific transistors were developed and brought to production status. Many types were manufactured in Southampton, Holland and Germany, with a single site in Holland producing refined germanium. You can see from Figure 20 - showing production line workers attaching leads to the emitter and collector pellets of early diffusion transistors – that production was still very much a manual process.

Mullard were arguably the most successful European transistor manufacturer in the 1950s, and this was no accident. Judging by the number of adverts and application notes they published, and the range of devices they produced, the company was fully committed to the technology and out-invested all the competition. Its success with germanium transistors somewhat delayed its investment into silicon-based technology, and consequently at the end of the 1950s, it was probably behind other transistor manufacturers. In 1961, Mullard merged its semiconductor business with GEC, to form Associated Semiconductor Manufacturers (ASM): Mullard seems to have been the dominant partner in the deal and the Mullard brand persisted on the devices, to the detriment of the GEC name.

Semiconductors Ltd

Semiconductors Ltd was formed by Plessey in 1957, producing transistors in a purpose-built factory in Swindon, Wilts. Over the years, Plessey had resisted the temptation of making valves, and had stuck to passive components. Initially, to allow the semiconductor business to build up quickly, transistor designs were licensed from Philco in the US, and the company gradually established its own range, so it qualifies for inclusion here. In late-1957, the company's adverts stated that 'prior to full production, transistors identical with those to be manufactured are being imported from the USA', so there was no intention to mislead potential

Figure 26: The 1950s-vintage Siemens Ediswan type R2285 'Transistor Test Set'.

Figure 25: The professional AVO model CT537 transistor and diode tester. Note the 1200V warning label, presumably used to test high voltage diodes.

customers as to the origin of what it sold.

In 1959, the company marketed its germanium and silicon devices as 'computer transistors, designed and tested to the special requirements of computer engineers ... the key to a new order of computer speed and reliability' and categorised them either as high-speed switching or as core driving. It's impressive that the company was already making a range of silicon transistors – no doubt with the help of Philco – realising that the future of the industry lay in that element, rather than in 'old technology' germanium. Figure 21 shows the broad range of germanium and silicon transistors the company was able to offer, mainly imported from the US at this stage.

Eventually the parent Plessey allowed the new company to call itself Plessey Semiconductors Ltd, a sure sign that the company was becoming a business success.

The association of Semiconductors Ltd with Sinclair Radionics of Cambridge is well known. Clive Sinclair (he was knighted in 1983) wrote for Practical Wireless in the late-1950s and in the magazine (and in books he wrote for Bernards publishers, see References 11, 12 and 13) he gradually evolved the circuits that would become his company's miniature radios, in the Slimline, Micro 6, etc. His early designs used mainly Mullard transistors (and occasionally red and white spots – see later), but his ultimate compact, low power designs specified transistors from Semiconductors Ltd, especially the SB344 high-speed low-level switching transistor.

Ever the businessman, in the 1960s, Sinclair sourced (presumably reject) transistors cheaply from Semiconductors Ltd, tested and remarked them, and used them in his own products – audio amplifiers and miniature radios. He even sold the transistors under Sinclair's own codes, the MAT100, MAT101, MAT120 and MAT121 in the early-1960s. I bought a couple of MAT100 a few years ago when I recreated a Micro-6 (though not at the same level of miniaturisation achieved by Sinclair) and the transistors I obtained had gold-plated leads and bodies, and even after so long they were perfectly solderable without cleaning. Sinclair also used the ADT140 for use in its FM/VHF products, such as the Micro FM tuner/receiver.

Hughes International (UK) Ltd

A range of 2N-series transistors, starting with the 2N706, were sold in the UK by Hughes International. The 2N706 is an NPN silicon device, and it's likely that this was imported by the company in the early-1960s, rather than the 1950s.

Hivac Ltd

In 1957 Hivac (from The High Vacuum Valve Company) advertised the XFT2 PNP germanium transistor, as 'the ideal small junction transistor, for hearing aids and other audio frequency applications'. The company had a history of producing miniature valves for use in hearing aids and other compact equipment (for example, the XR4 subminiature beam tetrode for use at up to 400MHz in hand-held radios), so perhaps a foray into miniature transistors made sense.

The advert incorporated the BTH (see below) logo, so it seems likely that the transistor originated at BTH. There also seems to have been a Hivac switching transistor, the TM1. It may be that the XFT2 was built into hearing aids, and the TM1 was used in some industrial controller, but data on these devices is difficult to find.

British Thompson Houston (BTH)

BTH was a Rugby-based electrical company, with early experience of working with germanium 'crystal rectifiers', used as frequency converters in war-time radars. After the announcement of the Bell Labs transistor, a small team was put to work experimenting with transistors based on germanium. The team was successful in manually building point-contact transistors (probably similar to the ones described in the Brewing Your Own Transistors section below) but no-one could work out what to do with them, and so work stopped and the team was disbanded in 1950.

At some later point, the company changed its mind, and after an informal exchange of information with Bell Labs (said to have been during a visit to BTH by Walter Brattain himself) transistors were again produced, presumably by now of the diffused junction type. A June 1957 advert in Wireless World indicated the existence of 'large quantities available from stock' of six small signal germanium transistors, with the code numbers GT1, GT2, GT2, GT11, GT12 and GT13. The cut-off frequencies ranged from 0.8MHz to 9MHz, and so they seemed to be useful for general use in radios, and in switching circuits. These transistors had the advantage of being very small: their cases were only 5/16-inch long.

An article in the August 1958 issue of

Practical Wireless specified GT12, GT13 and GT3 transistors for use in a 'Pocket Superhet' project, so indications are that these transistors were flowing freely and could be obtained by amateurs.

In 1958, BTH was acquired by AEI, and some later transistors were labelled with both company names.

British Tungsram Radio Works

This company, located in Tottenham, London, is mentioned in Clive Sinclair's book 'Practical Transistor Receivers Book 1' as a British transistor manufacturer. During the war, the company produced valves, and it may be that it experimented with transistors in the late-1940s / early-1950s. In 1952 it was acquired by Philips Electrical Ltd, and Mullard took over the day-to-day management of the British operation. If it did produce any working transistors, before or after the acquisition, no firm information seems to have survived.

Westinghouse Brake and Signal Co Ltd

Clive Sinclair also mentions Westinghouse as a UK transistor manufacturer in his 'Practical Transistor Receivers Book 1', but with no mention of the devices produced or their code numbers. I presume these were for internal consumption, and perhaps didn't have a long production lifetime, being replaced by devices from other manufacturers.

Brush Crystal Co Ltd

Brush produced a range of transistors, with codes beginning with 'CYT-', each with a direct '2N' equivalent. For example, the CYT-1549 is equivalent to the 2N1549, a PNP germanium power transistor in a T03 case. These seem to have been US-produced transistors, imported into the UK and marked with these Brush codes. In the UK, Brush also seems to have produced an extensive range of PNP germanium devices in their own 'OC' series, starting with the OC303.

Based on silicon, rather than germanium, the OC800 is worthy of more than a passing mention. Information on the device is very sketchy, and it may not have been manufactured until the very early 1960s, and so strictly speaking excluding it from this article. This was a junction field effect transistor (FET), and was probably the first FET produced in the UK (the first FET in the US was built in 1959).

Today's nomenclature for a FET's terminals – source, gate and drain – hadn't yet been adopted, and the OC800's base lead was called an 'anode'; its emitter a 'cathode'; and its collector a 'modulator'. The device was often referred to as a 'semi-conductor valve', reflecting its high impedance, voltage-controlled operation. The concept of the field-effect semiconductor device was patented as early as 1926, although contemporary manufacturing techniques were unable to make such a device.

The significance of the production of FETs was profound: the junction FET soon led to the MOSFET, and the ability to integrate P-channel and N-channel MOSFETs on the same die gave us CMOS. Being able to integrate vast numbers of transistors without the die melting, this low static current CMOS technology is what gives us the incredible logic density that we see on ICs today.

Joseph Lucas (Electrical) Ltd

In the field of semiconductors, Lucas concentrated on diodes, but also produced transistors, based on silicon, intended for use in military and industrial applications. Their transistors' part numbers start with 'DT', and it's possible that they produced their first transistors in the late-1950s, and so they just about qualify for inclusion here.

Texas Instruments Ltd

The UK arm of US-based Texas Instruments Inc (commonly referred to simply as TI), was set up in 1957 in Bedford, at a leased site in Dallas Road. In 1960 the company moved to its permanent site, at the famous Manton Lane address. Initially, the company made PNP transistors (for example, the 2G101), all the way from pulling germanium crystals to completed devices. Later on, silicon devices were produced, and were possibly the first to be produced in the UK, as TI was a pioneer in this technology and produced the first commercial silicon transistor in 1954. Of great significance, TI in the US invented and manufactured the first integrated circuit in 1958.

TI UK's early ranges of transistors had codes beginning with 2G, 2N and 2S, and it's probably impossible now to determine which ones were made in Bedford, and which were imported from the mother company.

Ferranti Semiconductors

For most of the 1950s, Ferranti concentrated on the production of germanium and silicon junction diodes and power rectifiers, mainly for use in high reliability systems, such as in aircraft, radar systems, guided missiles, process control and telephone equipment.

Although commercial Ferranti transistors

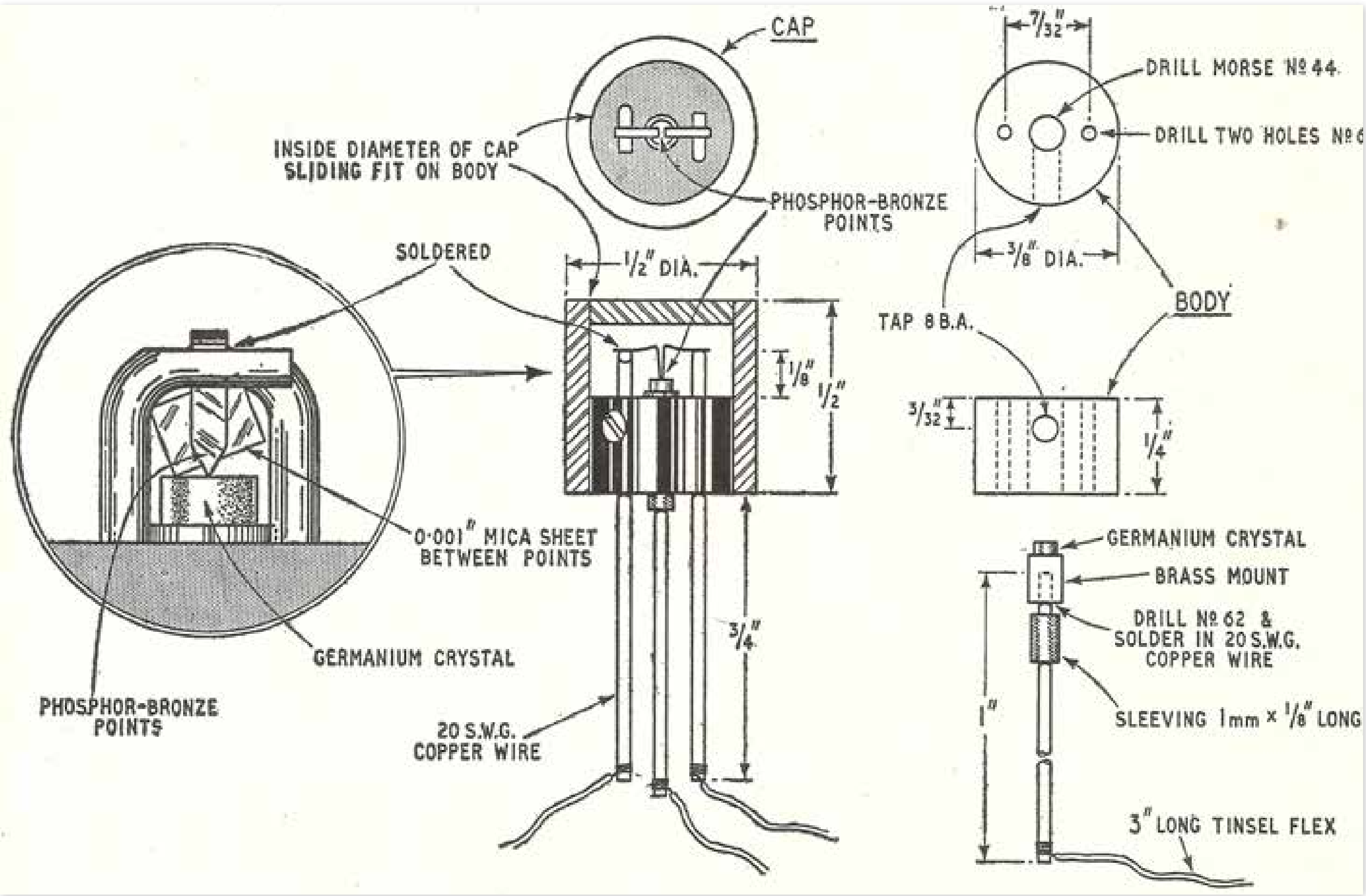
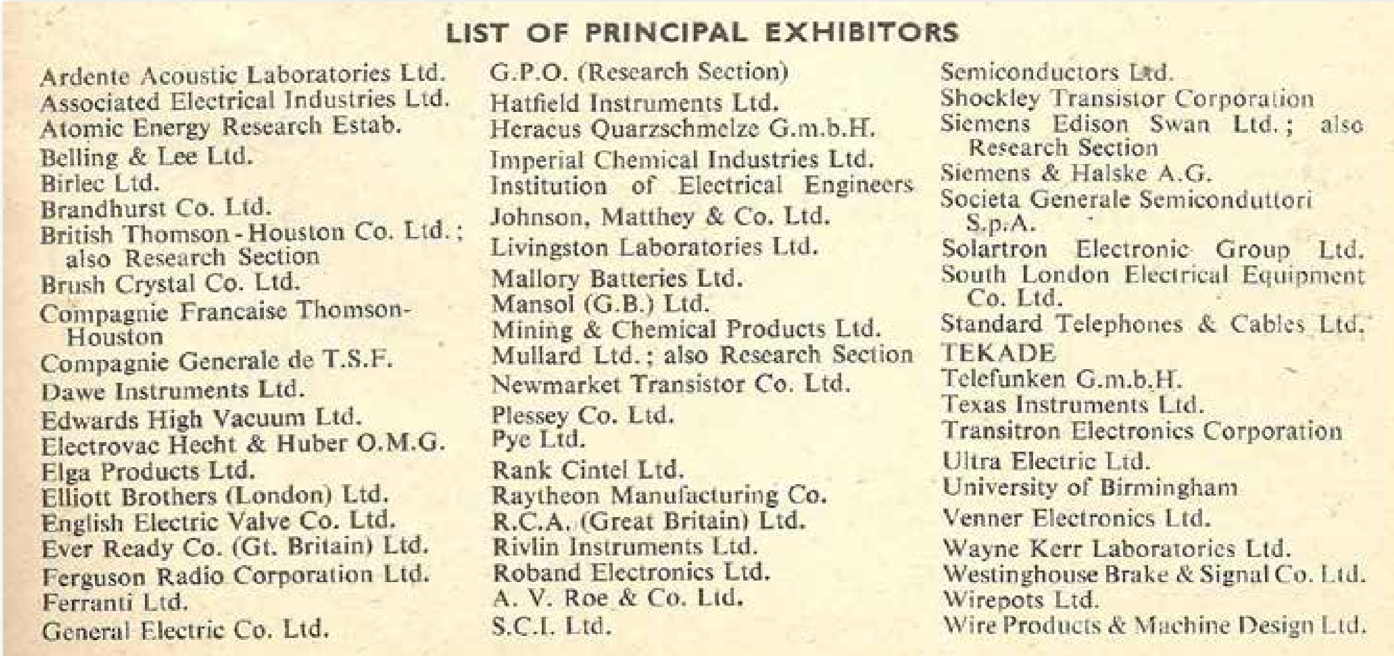


Figure 27: Constructional details of the home made point contact transistor, as described in the January 1954 issue of Wireless World.



LIST OF PRINCIPAL EXHIBITORS

Ardente Acoustic Laboratories Ltd.
Associated Electrical Industries Ltd.
Atomic Energy Research Estab.
Belling & Lee Ltd.
Birlec Ltd.
Brandhurst Co. Ltd.
British Thomson-Houston Co. Ltd.; also Research Section
Brush Crystal Co. Ltd.
Compagnie Francaise Thomson-Houston
Compagnie Generale de T.S.F.
Dawe Instruments Ltd.
Edwards High Vacuum Ltd.
Electrovac Hecht & Huber O.M.G.
Elga Products Ltd.
Elliott Brothers (London) Ltd.
English Electric Valve Co. Ltd.
Ever Ready Co. (Gt. Britain) Ltd.
Ferguson Radio Corporation Ltd.
Ferranti Ltd.
General Electric Co. Ltd.
G.P.O. (Research Section)
Hatfield Instruments Ltd.
Heraeus Quarzschmelze G.m.b.H.
Imperial Chemical Industries Ltd.
Institution of Electrical Engineers
Johnson, Matthey & Co. Ltd.
Livingston Laboratories Ltd.
Mallory Batteries Ltd.
Mansol (G.B.) Ltd.
Mining & Chemical Products Ltd.
Mullard Ltd.; also Research Section
Newmarket Transistor Co. Ltd.
Plessey Co. Ltd.
Pye Ltd.
Rank Cintel Ltd.
Raytheon Manufacturing Co.
R.C.A. (Great Britain) Ltd.
Rivlin Instruments Ltd.
Roband Electronics Ltd.
A. V. Roe & Co. Ltd.
S.C.I. Ltd.
Semiconductors Ltd.
Shockley Transistor Corporation
Siemens Edison Swan Ltd.; also Research Section
Siemens & Halske A.G.
Societa Generale Semiconduttori S.p.A.
Solartron Electronic Group Ltd.
South London Electrical Equipment Co. Ltd.
Standard Telephones & Cables Ltd.
TEKADE
Telefunken G.m.b.H.
Texas Instruments Ltd.
Transitron Electronics Corporation
Ultra Electric Ltd.
University of Birmingham
Venner Electronics Ltd.
Wayne Kerr Laboratories Ltd.
Westinghouse Brake & Signal Co. Ltd.
Wirepots Ltd.
Wire Products & Machine Design Ltd.

Figure 28: List of principal exhibitors at the International Transistor Convention, held at Earls Court in May 1959.

from the 1960s and later are fairly well-known - I recall using some of their very compact ZTX-series in the 1970s – references to their transistors pre-1960 are very rare. It may have been that they were using germanium transistors on military contracts, but their first commercial transistors were NPN silicon devices, appearing in about 1960.

Ferranti Radio and TV Ltd's first transistor radio, the PT1010, used the Ediswan XA101, XA102, etc range, but later radios used Mullard devices.

Sylvania-Thorn

'A new all-British NPN transistor' was how Sylvania-Thorn advertised a range of five germanium transistors, designated as GT422-GT426 in the November 1959 issue of Wireless World. The company had been set up in 1954 to make TV cathode ray tubes, but as you can see in Figure 22, it was now dabbling in transistors and had produced high voltage, high current switching devices, housed in what looks to be a standard TO3 package.

It may be significant that the full address of the company included the words 'colour television laboratories'. Colour TV didn't arrive in the UK until 1967 (and colour broadcasting in other major countries in Europe began in the same year) and so although several demonstration systems were tested in the UK in the 1950s, true public colour broadcasting was a long way off for anyone working in that laboratory. In the US, of course, colour broadcasting had started much earlier (in 1953) hence perhaps the connection with Sylvania. Assuming that the aim of the lab was to produce transistors for use in TVs, perhaps the management thought it would be a good idea to offer switching transistors to a more general audience.

Getting hold of transistors

In June 1957, a few transistors could be bought by amateurs by mail order. For example, Lasky's were offering a genuine OC71 for 24/-, see Figure 23. There are several ways of comparing a price in 1957 to what it represents today, generally relying on government data. I'll use a simpler method: the price of a copy of Practical Wireless in 1957 was 1/3d, that is, the OC71 cost 19.2 times as much as the magazine. Practical Wireless is still published, and today (June 2016) its cover price is £3.99. The OC71 in mid-1957 was therefore selling for the equivalent of more than £76 in today's prices. A generic 'red spot' transistor (see later) was about half this price. If you wanted an OC72 to use in an output stage (in fact you'd probably need two of them), you'd have to pay 30/-, equivalent to £115! It's therefore not surprising that experimenters were very careful with the way they handled the transistor, especially in the way they heatsinked the leads as they soldered the device into circuit. Some constructors used sockets to plug their transistors into, avoiding the problem of soldering the leads altogether.

Note that Lasky's were also selling early Brimar transistors, including the original point contact devices, the TP1 and TP2. Though it may seem like obsolete technology, the TP2 was capable of working at up to 2MHz, whereas the fastest TS transistor would only run at 500kHz.

Surplus transistors

In the early days of transistor manufacture in the UK, the only way amateur experimenters could get hold of a transistor was as an unbranded 'paint spot' device. The only marking on these devices was a blob of paint, indicating its type. For example, a 'red spot' was capable of amplification at audio frequencies, and was advertised as being approximately equivalent to a Mullard OC71. When I first became interested in electronics in the mid-1960s, I bought a 'red spot', and remarkably, I still have it (see Figure 24). Presumably I saved up my pocket money and paid 10/- for it. I tested it recently on an Atlas DCA55 component analyser, and it still works – it indicates an hFE of 26. I must get round to building my 'red spot' into an audio amplifier, and make it do some useful work for the first time in 50 years.

A little later, a 'white spot' capable of running at 5MHz or so, and a 'green spot', capable of 8MHz appeared. The Lasky advert shows 'double spot' transistors: the yellow/red is a good general purpose RF/IF transistor, and the yellow/green device is useful in audio amplifiers and output stages.

Testing transistors

From the earliest days of transistors, with many surplus transistors around, constructors wanted to check that their valuable possessions were intact, and so there was a demand for testers. Many articles were published in the amateur and professional press, describing both simple go/no go versions and more complex testers that were able to effectively plot the characteristics of the device. Kits were offered - several by Heathkit of course - and these are very desirable and are often seen on eBay selling for good prices.

One professional diode and transistor tester I have is an AVO model CT537 (see Figure 25). My tester was clearly used in the services, and to be more exact, the navy – if the 'HMS Berwick' label is to be believed. I thought at first that HMS Berwick was perhaps a shore-based training camp, but it seems to have been a 'real' ship. According to Wikipedia, since 1679, there have been no less than ten ships that have borne the name, and the only one likely to have carried the AVO tester was commissioned in 1961, and sunk as a target ship in 1986.

The operating instruction manual for the CT537 shows a schematic, and it uses no less than 14 transistors, from Mullard, Newmarket, STC (a BSY95A) and a specially selected Texas 2S304. As you can see this tester is rather evocative of a valve tester, several models of which AVO manufactured of course, and is very well made, and clearly an expensive instrument, and probably well out of the league of an amateur when it was being sold. I presume that ships carried valve testers to enable them to service receivers and transmitters, and perhaps it was thought that any transistorised equipment should also be serviced, down to the diode and transistor level. I must admit I bought it on eBay as a whim, there not being many bidders for it, and I've never used it in anger.

Another professionally-built transistor tester I have is the 1950s-vintage Siemens Ediswan type R2285, see Figure 26. The die-cast metal cabinet is only 7-inches wide, so it's a very portable unit, and is operated from an internal PP4 9V battery. You can see the cut-out and grille for an internal speaker, which then drives the speaker via an XC101. The R2285 tests for leakage current and common emitter current gain only on PNP transistors, which presumably were the only transistors Ediswan were making when they designed the tester. Instructions for how to operate it are printed on the back of the cabinet. My tester has the serial number 429, so it looks like quite a number of them were built, and I've seen a few around over the years. Mullard, STC and other transistor manufacturers also made testers for their early devices.

In 1957, Tektronix advertised its Type 575 Transistor Curve Tracer in the UK, capable of testing PNP and NPN transistors. This looked very much like one of their 'scopes, with a circular CRT screen and the necessary controls for setting various transistor parameters. The instrument would then sweep across ranges of input voltage or current conditions, and display the curves on the screen. The 1957 price for the Type 575 was £373 – definitely an instrument for a professional laboratory.

Other transistor manufacturers

The list above represents the manufacturers of the vast majority of transistors in the UK in the 1950s. However, there would have been other organisations that carried out research into the technology, and probably went as far as producing transistors in small numbers in pilot plants. I include in this category the GPO (with interest in the use of transistors in transmission equipment, in exchanges, and in submarine cables); the MOD; and Universities. As the likes of GEC and Mullard found out, the difficult trick is being able to make diffusion transistors reliably in large volumes, with the right performance, and at the right price. Some of these early transistors may have escaped and may still be around.

Brewing your own transistors

In January 1954, Wireless World published an article by P B Heldson describing how to fabricate transistors at home (see Reference 14) using germanium diodes as a starting point. Figure 27 is a diagram from the article, which shows how the transistor was constructed - it was mainly an exercise in fine mechanical engineering.

The phosphor-bronze points were recovered from germanium diodes, as was the germanium crystal used as the base region. The 0.001-inch gap between the emitter and collector contacts was set by slipping a fine sheet of mica between the phosphor-bronze points. The collector region was formed by discharging a 0.01µF capacitor, charged to 250V, between the collector lead and the crystal for as many times as it took to create a reverse-resistance of about 8kΩ. This process inverted the N-type material in the collector region of the germanium crystal into P-type, and bonded the collector lead into the crystal. As far as I can see, the emitter junction was simply at the point where the second phosphor-bronze point contacted onto the germanium (giving a metal-semiconductor junction) and the whole device was held together with a blob of wax. The transistor so formed was unreliable, and not very useful, but it could amplify, and the person who had built it had the satisfaction of replicating a delicate and revolutionary process. The exercise would have created a point-contact transistor, similar to the type built by the team at Bell Labs in 1947, which was obsolete and not very useful by 1954.

A similar article appeared in Practical Wireless in May 1955, authoured by H T Noar (see Reference 15). Mr Noar's construction technique was very similar to the Wireless World method, except that he recommended a wider mica sheet, of 0.002-inch. Again, a point-contact transistor was described and capacitor discharge was used to form the collector region.

The 1959 International Transistor Convention

A convention was held in Earls Court in May 1959, and was attended by the majority of British Transistor manufacturers, makers of components associated with transistor circuits, and other interested parties. Figure 28 shows the proposed list of principal exhibitors, as shown in Practical Wireless for June 1959 (presumably the issue was published in May). Acknowledging the international importance of the event, John Bardeen, Walter Brattain and William Shockley were what we would call today 'keynote speakers'.

The invitation to the convention said: 'Transistors – three bits of wire leading from a germanium crystal enclosed in a vacuum inside an aluminium tube protected by silicone grease – represents one of the most outstanding scientific and technical achievements of the post-war period, and they have had an enormous influence on many branches of electrical engineering', and called for an exchange of international knowledge on the transistor and its applications. I think the fact that the convention was held in the UK, and the long list of British manufacturers, show the strong position of the industry in the UK at the time.

Summary and conclusions

Although it was not obvious at the time, the seeds of the British semiconductor industry were sown in the 1930s by the development and production of 'metal' rectifiers, based on copper oxide and selenium, and later devices, based on germanium. Companies who had experience with germanium were in a good position to start to design and manufacture transistors based on this material. Judging by the number of companies who produced (presumably) working transistors in the UK, the technology must have been relatively accessible, but to predictably make reliable diffused junction devices in commercial quantities and at reasonable prices was much more difficult, and only a few companies achieved this.

In this article, with a small number of exceptions, I've tried not to 'spill over' into the 1960s (and later) and hence I haven't detailed the eventual demise of many of these attempts at making commercially-viable transistors. There was a mortality rate of British companies trying to make transistors, just as there was in those trying to make a commercial success in making radios using these devices, as the rate of import of foreign products accelerated in the 1960s and 1970s.

It should not be imagined that transistors displaced valves quickly: during the 1950s, all valve manufacturers, including Mullard, Osram and Brimar, were producing new valve designs. For example, the EL84 and EL34 were introduced in the 1950s, several years after the transistor had been invented and at a time when Mullard were deeply committed to the future of the transistor.

Figure 3: The range of transistor radios offered by Radio Exchange Co, Bedford, in 1959, in the form of kits using one, two, three, and four transistors. These designs were typical of many simple transistor radios being offered at the time.

References

Reference 1: Information on early British computers using transistors can be found at: http://www.wylie.org.uk/technology/computer/britcomp.htm

Reference 2: 'A Computer Called LEO' by Georgina Ferry. Published by Fourth Estate in 2003. A very readable history of J Lyons & Co Ltd, and how the needs of their teashop business drove the creation of Leo Computers Ltd, and the LEO range of computers.

Reference 3: 'The Early Days of Digital Computing in the British Army' by Ken Anderson MSc. Published by Las Atalayas Publishing in 2007. The book mainly covers the post-1960 period, but contains many interesting photos of early computers and the technology used to build them.

Reference 4: 'Early British Computers' by Simon Lavington. Published in the UK by Manchester University Press in 1980. After a brief introduction to early mechanical computers, the author concentrates on the period of great innovation from 1945 to 1955, describing the technology (including the first transistor-based computers) used and the architecture of the computers themselves. For any software programmers in the readership, the chapter on early programming techniques will be particularly interesting.

Reference 5: The on-line Hearing Aid Museum can be found at: http://www.hearingaidmuseum.com/index.htm.

Reference 6: A very readable and informative account of the use of transistors in Explorer 1 is presented as an oral history at: http://semiconductormuseum.com/Transistors/LectureHall/Ludwig/Ludwig_Index.htm

Reference 7: 'The Transistorette' by G A French. Published in Radio Constructor, February (and subsequent months) 1956.

Reference 8: 'Transistors and Crystal Diodes - What they are and how to use them' by B R Bettridge (of GEC's Osram Valve and Electronics Department). Published by Norman Price (Publishers) Ltd in 1954.

Reference 9: 'Transistors in Television', published in Wireless World for April 1957.

Reference 10: 'British Transistor Directory' by E N Bradley. Published by Norman Price (Publishers) Ltd in 1963.

Reference 11: 'Practical Transistor Receivers Book 1' by Clive Sinclair. Published by Bernards Ltd, initially in 1959, and with many subsequent reprints. From the perspective of this article, the book gives a 'snapshot' of British transistor manufacturers, and their transistors, in 1959.

Reference 12: 'Transistor Subminiature Receivers Handbook for the Home Constructor' by Clive Sinclair. Published by Bernards Ltd, initially in 1961, and with several reprints.

Reference 13: 'Transistor Audio Amplifier Manual' by Clive Sinclair. Published by Bernards Ltd, initially in 1962, and with several reprints.

Reference 14: 'Home-Made Transistors – Inexpensive Conversion of Selected Germanium Diodes' by P B Heldson. Published in Wireless World, January 1954.

Reference 15: 'Making Transistors – How to use surplus diodes in the construction of modern transistors' by H T Noar. Published in Practical Wireless, May 1955.

Other References

Andrew Wylie's very interesting research into transistor development in the UK, including many pictures of the early devices in his collection, can be found at: http://www.wylie.org.uk/technology/semics/ukindust.htm

The US-based Transistor Museum can be found at: http://www.semiconductormuseum.com/Museum_Index.htm

Another transistor history site is at: https://sites.google.com/site/transistorhistory/Home

The brand history of many transistor and diode manufacturers, including some UK ones, can be found at: http://transparentsound.com/transistors/vintage-transistors/brand-history/brand-history.htm

Some useful data on early germanium transistors can be found at: http://vintageradio.me.uk/info/germanium.htm

Philips published 'A Brief History of the Southampton Plant 1956-1996', and a scan of this document is at: http://pepnet.org.uk/yourarticles/Southampton/History.pdf

'Transistor History at Philips/Mullard' by Arnaud Cramwinckel. Published in the winter 2009 issue of the BVWS Bulletin, is an informative account of how Philips / Mullard developed their first transistors and grew into the dominant semiconductor manufacturer in Europe.

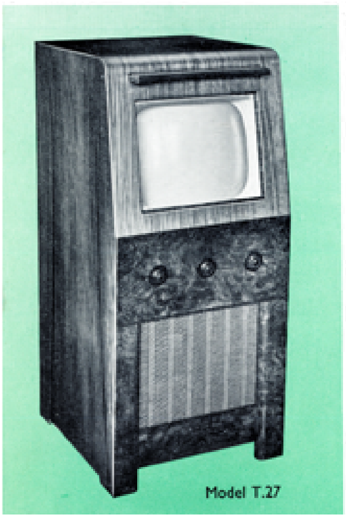
'Transistor Radios Circuitry and Servicing' published by Mullard in 1962. For those interested in how germanium transistors were made by Mullard and how they worked, this booklet contains very useful chapters on semiconductor materials, manufacture of transistors and transistor action,

A useful 'launch page' for information on early British computers is at: https://en.wikipedia.org/wiki/Category:Early_British_computers

The Computer History Museum, giving an early history of the transistor, and its impact on computers can be found at: http://www.computerhistory.org/siliconengine/the-european-transistor-invention/

Some early transistor-based computers can be seen at The National Museum of Computing, at Bletchley Park, Milton Keynes, MK3 6EB.

'Selecting Transistors' by J Brown is a useful source of UK transistor manufacturers in 1959, and the devices they were making. Published in Practical Wireless, December 1959.



Model T.27

MODEL T.27

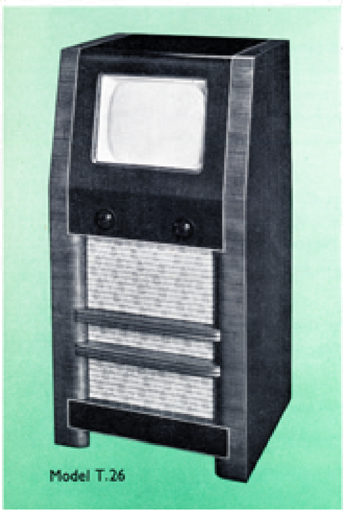
This attractive receiver, which incorporates a 15" BAIRD "Cathovisor" Tube, has been designed for the reception of vision and its accompanying sound, so giving complete entertainment. A picture 12" wide x 9¼" high is produced and direct viewing is featured. The handsome cabinet is veneered with choice straight grained walnut, artistically relieved with selected burr. A special sliding panel is inbuilt, a two-fold advantage. Firstly it considerably enhances the appearance when the receiver is not in use, and secondly proves a definite advantage by acting as a screen when, on occasions, overhead room lights are in use.

DIMENSIONS:

44½" High : 20" Wide : 22½" Deep

Model T.27 for A.C. Mains, 190-260 v. 50 cycles

PRICE **48** GUINEAS



Model T.26

MODEL T.26

Model T.26 is the vision and sound receiver complementary to Model T.25. The size of the picture is again 10" wide x 8" high and viewed direct. Provision is made for receiving television sound only, so permitting the B.B.C. High Fidelity transmission on the television sound wavelength to be received independently of vision. The cabinet is available either in figured walnut or sapeli mahogany.

If the latter is desired a small additional charge is made of 30/-

DIMENSIONS:

40" High : 20" Wide : 18" Deep

Model T.26 for A.C Mains, 190-260 v. 50 cycles

PRICE **40** GUINEAS

A Nostalgic Project

By Peter Lankshear

Before the mid 1950's, home radio construction was a popular hobby. Radio magazines were plentiful and most published details and instructions for projects ranging from beginners' crystal sets to quite elaborate multi band receivers. Accompanying these articles would be advertisements from suppliers of parts and kit sets. Many of the most enthusiastic readers were technically inclined lads who salvaged, scrounged, recycled and traded parts and saved pocket money, often earned by jobs out of school hours. I was one of these and it led eventually to my making electronics my life's work. To be able to make a career from a hobby is an enviable situation.

A competition

There was a special satisfaction in building a radio that worked and I was interested when recently the NZ Vintage Radio Society announced a project with which I could indulge in some nostalgia. They planned a competition for a project that could have come out of an old radio magazine. It was for the design and construction of a simple receiver, to be capable of receiving signals in the M.W. band. Novelty would earn points and the number of active devices in the signal path was limited to four. There were few other specific requirements, but one was for the addition of a headphone output suitable for supplying a test signal into a 1000 ohms termination. A clarification stated that diodes would not be classed as active devices.

Arguably the "Golden Age" of valve radios was the period immediately prior to World-War II. The major developments in A.M. receiver evolution were in place and the International Octal based valves used widely were reliable with good performances and available from many manufacturers. The outbreak of war in 1939 had brought most domestic receiver development to a halt, and in the immediate recovery period after 1945, manufacturers understandably took over from where they had left off. This appeared to be a good period to base a receiver on.

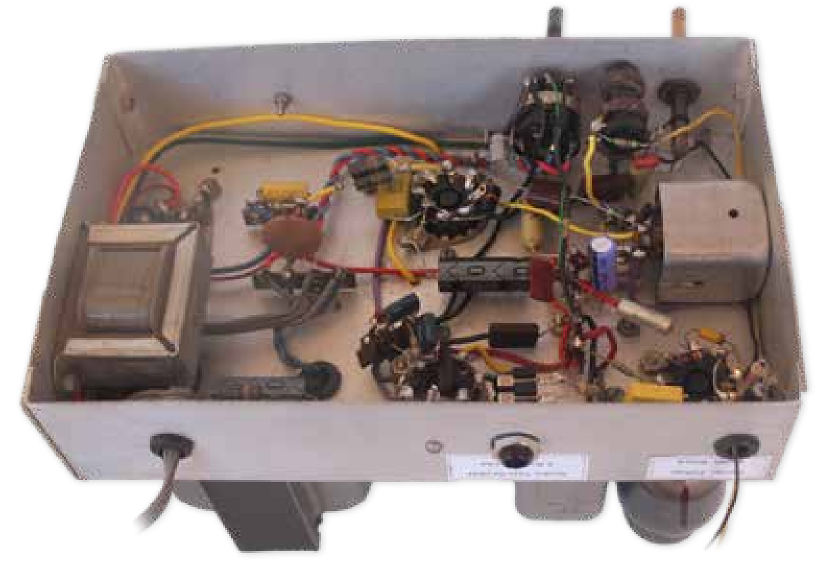
Although a standard four valve plus rectifier superhet could fit the rules of the competition, for a maximum of four active devices, it would have little novelty and would be unlikely to excite the judges and might not strictly meet the requirement of simplicity. Better to make something less common and preferably less complex.

Three stage receivers

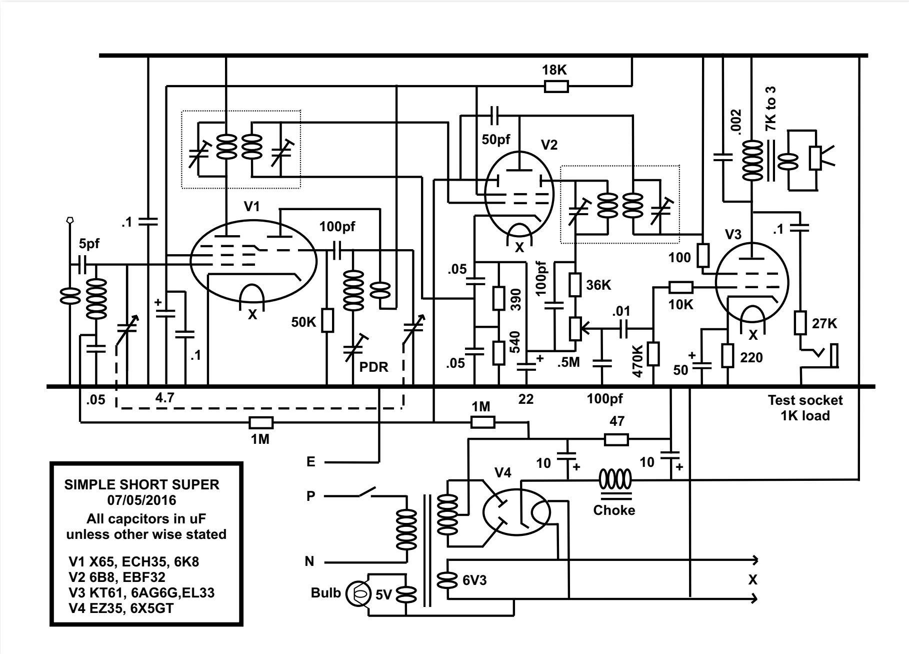
Other than sets with regenerative detectors, which were obsolete by the early 1930's, the simplest valve receivers capable of serious work had three stages. Popular in America especially were inexpensive TRF receivers with an R.F. stage, a detector and a loudspeaker amplifier stage and a fourth valve, a rectifier. Intended for urban locations these radios were limited in sensitivity and selectivity. A circuit of a typical receiver is attached shown on the next page. Suitable for receiving local stations only, they were commonly found in apartments or in use as "second sets" for kitchens, bedrooms, dens, children's radios and the like. Whereas even a basic superhet would have four or five tuned circuits, a three stage TRF would have only two tuned circuits and therefore limited selectivity. There were also a few simple sets that had a frequency converter connected to the detector without the benefit of an I.F. amplifier. Although they had slightly better selectivity than the simple

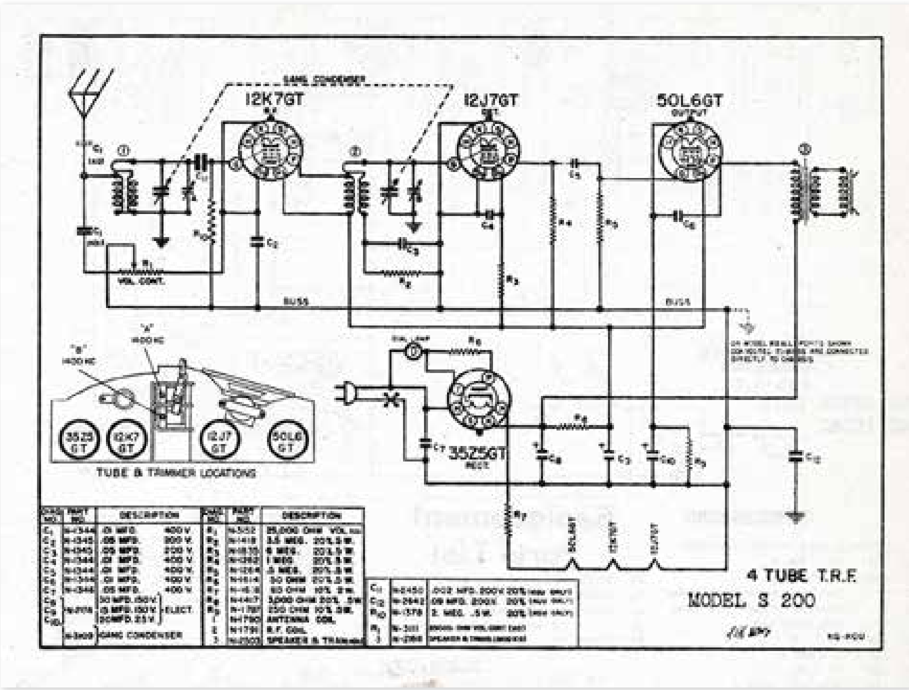
Chassis front

Chassis rear



Chassis underside.





The TRF circuit could be labelled "Typical small inexpensive American TRF from 1942. This example was sold by Gamble-Skogmo, a large department chain store organisation.

TRF's they were still very basic receivers.

Little known outside Europe and Britain, were the far better performing "Short Superhets"- fully functional superheterodynes, also using only three valves plus a rectifier. Many British manufacturers made them, some well-known examples being the pre-war Philco "People's Set", the Wartime, Government sponsored, "Civilian Receiver" and the very collectable circular A22 Ekco.

The standard superhet with its two audio stages, had a surplus of audio gain that could be useful for weak signals and shortwave reception, but otherwise was largely wasted. The short superhet was simplified in having the detector directly driving a single audio stage without an intermediate voltage amplifier. In these receivers, the use of high gain output pentodes went some way to compensate for the reduced audio gain.

It seemed that a short superhet could meet the requirements of the contest and be a practical and useful receiver after the competition.

The circuit design

A search through the many years' accumulation of useful bits and pieces in my "used but too good to be thrown away" box revealed a small square dial unit and associated tuning capacitor. They had been supplied by the long deceased Auckland firm of Johns Limited who made "Companion" receivers and components. Although used in various projects since their purchase in 1947, they were in reasonable condition, from the right era and were suitable to base a receiver around. Suitable aerial and oscillator coils were located and a pair of New Zealand made, "Inductance Specialists", excellent iron cored I.F. transformers were also found.

The first valve would be the frequency converter, with several interchangeable types of octal triode/hexode readily available. The circuit would be standard other than the use of "back" bias for the control grid, whereby a capacitor was saved by returning the AGC line to a 47 ohm resistor in the power supply negative lead.

In a short superhet especially, the I.F. amplifier valve provides a significant proportion of the receiver gain. As semi conductor diodes were not in common use for detection and AGC before 1950, either the I.F. amplifier or the output valve would need a pair of diodes included in its envelope. The Philips EBL1 diode/power pentode had been intended for this type of service. However, I had none so chose a metal 6B8 diode/R.F pentode, a rugged and reliable performer, for the I.F. stage and detector. A simplification of the circuit was to use a common single resistor and bypass capacitor for the voltage supply to the IF screen, the mixer screen and the oscillator anode supply.

Diode detectors often also provided the automatic gain control voltage. Although simple and trouble free, this basic method has shortcomings in a short superhet. One problem is that even a weak signal will commence to reduce the gain of controlled valves. The remedy is to delay the onset of AGC so that only stronger signals will generate a control voltage. This entails the unavoidable complication of a second diode. Delayed AGC has also the advantage of creating a flatter control so that when it is operating, stations are more alike in received strength. It was

The finished product.

common practice to use the cathode voltage of the valve containing the diodes to provide the delay. As the cathode voltage of the 6B8 is only three volts, an extra cathode resistor was added to provide sufficient AGC delay to enable the detector to have adequate signal level to fully drive the output stage. As the 6B8 does not have a fully remote control grid cut-off, AGC was not applied to the I.F.stage.

High gain output valve

With a rated mutual conductance of about 10ma/v, the high sensitivity 6AG6G output pentode and its equivalents have twice the gain of many of their contemporary output pentodes. For high gain valves, cathode bias is recommended and to insure against parasitic oscillations, both the control and screen grids should have series connected suppressor resistors. A simple resistor/capacitor feed to the headphone test socket was fitted to comply with the judging rules. The output stage is otherwise quite conventional.

The power supply has a full wave rectifier and choke filter. As noted previously, the 47 ohm resistor in the negative lead supplies 3 volts bias for the frequency converter control grid.

Aluminium chassis

For this type of project aluminium being corrosion proof and easily worked, is a very satisfactory chassis material. A piece of 1.00 mm aluminium sheet made a very acceptable chassis. Its only shortcoming is that it can't be soldered but provided star washers are used with solder lugs, earthing is not a problem.

With the receiver operational, there remained the decision as to what to do about a cabinet. Cabinets for many receivers of this type were made of a moulded plastic,- hardly a practical material in a home workshop. Wood is the usual standby, but to produce anything more complex than a plain box requires tools and skills I don't possess. Leatherette covered wood seemed promising, so I marked out a sheet of 10mm plywood and a friend's jig saw was used to cut out the dial and speaker openings. After the cabinet's assembly, I approached an obliging car trimmer and upholsterer about obtaining some suitable leatherette. He was quite intrigued by the idea of using it to cover a cabinet and suggested brown head lining, which he offered to fit for me. This he did very promptly and at a very reasonable cost, and we were both very pleased with the result.

Some projects come together nicely with few problems. This was a good example, and the set works and sounds well. In an urban location and connected to a couple of metres of aerial, it receives all the local stations with sufficient audio gain to fully drive the output stage. It is now more or less permanently installed for service in my living room.

Neglected collectibles

The question may arise as to what is the relevance of this exercise to vintage radio.

Although home made and kitset radios were a significant part of radio history they are rarely seen in collections. They may not always have the finish and eye appeal of the commercial product but perhaps we should consider rescuing more of them to preserve alongside the more photogenic commercial products.

Acknowledgement

My thanks to Gary Tempest for using his computer skills to draught the circuit.

National Vintage Communications Fair
Sunday May 15th 2016 photos by Alex Hewitt


4
TRACK
Pye
Record Maker
Simon Sound Service
Boosey & Hawkes


W


RACAL


HITACHI


SONY


WALMLEY CLASSICS
RADIOS
0121 311 1588


TIME ZONE CHART OF THE WORLD

BAIRD TELEVISION

MODEL T.28

A console model incorporating a vision and sound receiver with 9" "Cathovisor" Tube. The picture is 7¾" wide x 6¼" high and viewed direct. The cabinet is very distinctive in design and constructed of walnut with a facing of Indian laurel. In view of the extreme compactness this receiver should find a special appeal with flat owners, etc., and where space is an essential consideration.

DIMENSIONS:

37½" High : 15¼" Wide : 14½" Deep

Model T.28 for A.C. Mains, 190-260 v. 50 cycles

PRICE **33** GUINEAS

MODEL T.24

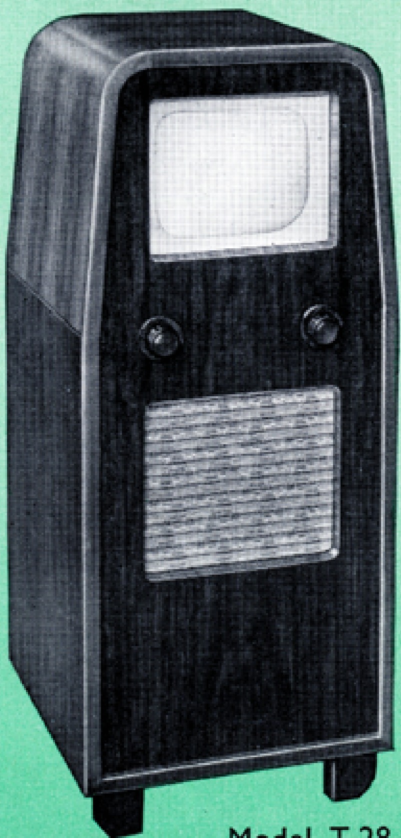
This is the table version of Model T.28 and incorporates all its many attractive features. The size of the picture is again 7¾" wide x 6¼" high and viewed direct. Simple in operation, it is possible, without any technical knowledge, to obtain consistently excellent results. The cabinet is very compact and is handsomely finished in burr relieved with straight grained walnut.

DIMENSIONS:

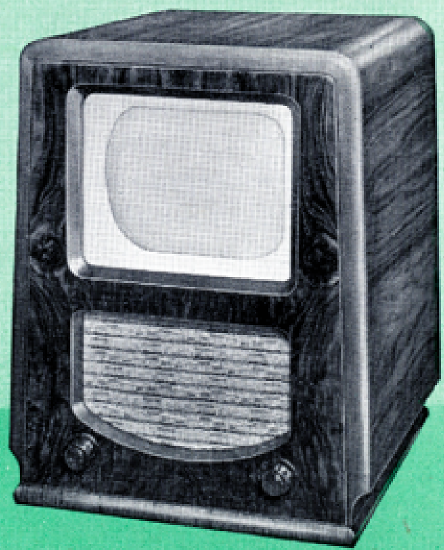
19½" High : 15" Wide : 14¾" Deep

Model T.24 for A.C. Mains, 190-260 v. 50 cycles

PRICE **30** GUINEAS



Model T.28



Model T.24

REMARKABLE CLARITY ✶ STEADY PICTURE ✶ EASY CONTROL

MODEL T40AW

Years of research and experiment have brought ULTRA TELEVISION to a high degree of technical efficiency and entertainment value. The remarkable performance, both for quality of picture reproduction and the faithful rendering of the accompanying sound, is an amazing achievement. Every latest technical refinement has been incorporated, in addition to many new features exclusive to ULTRA. The All-Wave Radio Receiver chassis assures effortless reception of World-wide Broadcast stations. You too can now enjoy this thrilling new entertainment in your own home !

ULTRA TELEVISION

MODEL T40 AW — DE-LUXE MODEL FOR SOUND AND VISION with ALL-WAVE RADIO

De-Luxe nineteen valve Receiver for television sound and vision and world-wide broadcast reception on Short Waves, 16.8-50 metres ; Medium Waves, 200-550 metres ; and Long Waves, 900-2,000 metres. Black and white picture 10″×8″ seen in mirror fitted in the cabinet lid. Seven-stage superheterodyne broadcast receiver giving 3.5 watts output. Cabinet in fine inlaid veneered Walnut.

Size : 40½″ high ; 32″ wide ; 16⅜″ deep. **70 GNS**

ULTRA TELEVISION

Ultra Television Models are installed in your home without extra charge by Ultra Engineers and left in perfect working order. This service is supplementary to the TWELVE MONTHS GUARANTEE which is given with all ULTRA TELEVISION RECEIVERS and is a ready assurance that you will have complete enjoyment of the Televised programmes with the same spontaneous appreciation as with normal Radio Broadcasts. Cathode Ray Tubes are separately guaranteed for 12 months by the manufacturers, and the standard B.V.A. guarantee applies to the valves.

Where special Di-pole Television Aerial is required, 3 gns. to 5 gns. extra.

Celebrating 80 years of BBC high definition television at Alexandra Palace By Mike Barker

The 2nd November 2016 marked a very significant 80th anniversary of the world's first regular high definition television service.

Alexandra Palace regeneration team members Kirsten Forrest and James White organised a small gathering of television historians, engineers and those connected with the television studios over the many years it operated. This was to be a general social event. A presentation was given by John Escolme and Robert Seatter (head of BBC history), they announced the opening of the BBC online resource 'The History of the BBC' which can be viewed at www.bbc.co.uk/historyofthebbc

To help mark this anniversary we decided to take along a restored 1936 Marconi 702 television. The idea being that we could show both the Baird 240 line and the EMI 405 line systems from two separate converters and just switch between them so that the audience could see the differences. As expected, almost no one there had ever seen the Baird system as it was discontinued in February 1937. This turned out to be a very special afternoon as we were lucky enough to have Iain Baird, JL Baird's grandson in attendance.

The Marconi television owned by Russell Atkinson that I had restored back in 2009 behaved itself all day giving a good steady picture throughout the afternoon and all through the evening.

We had the pleasure of meeting and chatting to Lily Fry who was a dancer on the live broadcasts in the early months of the television service. Lily at 92 yrs. Can still tap dance and told us 'I am not a star, I am only here because I am still alive you know'. She is a lovely lady and was thrilled to be able to meet Iain Baird.

Once the afternoon session had wound down we headed off for a pint in the bar at the other end of the Palace and waited until it was time for the evening sessions to begin where once again the Marconi 702 was switched on for the evening.

The first evening session kicked off with cocktails and nibbles in a 1930's style. The speaker for this part of the evening was Dr. Hugh Hunt who talked about the Baird mechanical spotlight scanner and the experiments he and his team at Cambridge University had performed in building such a device. This was illustrated by live demonstrations complete with spinning discs and cordless drills! This was followed by a unique performance of improvised comedy by 'Do Not Adjust Your Stage' (DNAYS), a troupe who form the comedy from the material of the speakers talk.

The second part of the evening opened with Prof. Danielle George talking about the EMI all electronic system of television and once again after the talk we were treated to a second performance from DNAYS.

After each evening session the audience were invited to view the television systems running on the Marconi 702. I was taken back by the number of people who asked intelligent questions about the TV and wanted to see if it really was a working TV of

back row L to R: Russell Atkinson, Don McLean, John Thompson - front row L to R: Jeff Borinsky, Paul Marshall, Mike Barker

The television aerial illuminated in the evening sky.

1936. The back cover was removed so that people could see the valves glowing and the enormous tube hanging in its cradle.

Once everything was over we packed up and set off for home shortly after midnight.

My thanks go to Russell Atkinson who allowed me to transport his valuable television to Alexandra Palace for the demonstration and to Jeff Borinsky for the loan of the 240 line converter.

Russell Atkinson and Lily Fry

Lily Fry and Iain Baird

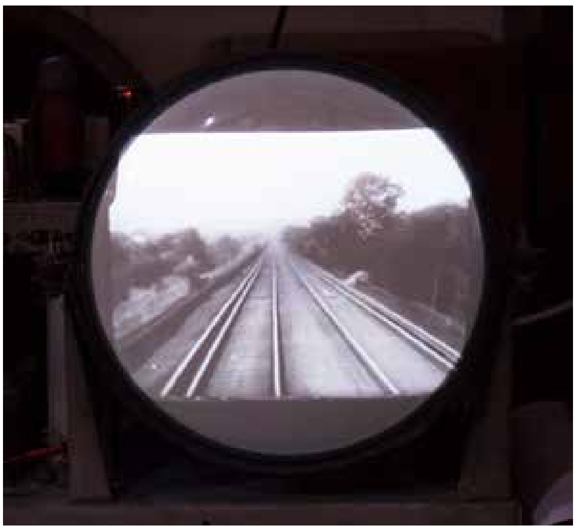
Television 80th Anniversary Event at BVW&TM 10th September 2016 photos by Greg Hewitt

Sony KV 1320-UB


Murphy V180


Bush TV24 and Pye V4

Murphy V1913 ‘Acoustic Deluxe’ Muprhy v204 15” Murphy V250 Portable



Murphy ‘Acoustic Deluxe’ 1967

A view of the BVWTM Television Gallery - Note the VCR97 home built TV at the back

1945 Invicta

Alexandra Palace Display

Bush TV22

KB Royal Star

Ekco TSC48 HMV 907, 1938 Bush TVG24 Murphy A56V Bush TV1

Television comes *back* to London

By Mike Barker

Some while ago at a garden party held at the British Vintage Wireless & Television Museum a visitor arrived with a Bush TV22 hoping that someone could get it going.

Bush TV22 on soak test in the workshop before return to its owner.

Bush TV22 being demonstrated.

Front of Broadcasting House, London.

Whilst passing through Gerry's workshop that day I joined the gathering of people who were eagerly watching this television being given volts for the first time in many years.

After a few moments the usual 'Bush dropper' smell was evident and filaments could be seen glowing through the dust covered valves.

More time passed and the gentle knocking sound of the frame blocking oscillator could be heard accompanied by some much distorted sound from the loudspeaker.

Still no signs of a raster or line whistle could be detected. Some knob twiddling then occurred and a very poorly sounding line oscillator could just be heard straining to do its job.

With voltages checked and a general agreement that the line output stage was at fault our attentions turned to the line output transformer (LOPT). A check to see if the PL38 grid was getting any drive showed that although weak, the drive was there. A spark check on the EHT rectifier anode produced ticking noises in the loudspeaker, but nothing visible to the naked eye.

The LOPT was condemned as the general problem and eye's turned upon me with a view to a rewind. Knowing that I was in a situation where I could not say no, I agreed to take the TV22 away and restore it.

It was at this point that I found out the set belonged to a BBC Editor and details were exchanged. The TV22 was given a full and complete restoration and the LOPT was removed and rewound. I won't bore you with the restoration details as they have been well covered by other authors in the past. When the set was working it was evident that the tube was quite low and had a nasty ion burn of a rather strange shape which really gave you a point of focus to draw the eye to and spoilt the job. A very good replacement Mullard MW22-16 with ion trap was installed to replace the tired MW22-18 and after about 15 minutes of setting everything up a picture which showed just how good a TV22 can be was obtained.

At this time, life got in the way of returning the set to the owner and it had to be packed up and put into store whilst we moved house and radio collection. Much water passed under the bridge and when some years later I could actually get to where it was stored it was once again brought out and tested. Thankfully it worked as well as the day it had been packed away and so after some soak testing, the owner was contacted to arrange a delivery. It was suggested that we deliver it to his place of work at the BBC where he would give us a short tour behind the scenes. This turned out to be Broadcasting House in Portland Place London.

So on a cold and bright December morning myself, Jim Hambleton and Russell Atkinson set off for London with a large cardboard box in the back of the car. When we arrived we were directed to an underground BBC car park close behind Broadcasting House where we were met by the owner. Thinking that we would just exchange the box from one car to another I was surprised when it was suggested that we take it into Broadcasting House and show it working. The owner had obtained a Domino standards converter some time before and I knew this so had made the aerial lead to suit. However the Domino does not contain a test card or other image unless an external source is plugged into it.

By luck, I still had an Aurora with some other bits in the back of the car and so we used that.

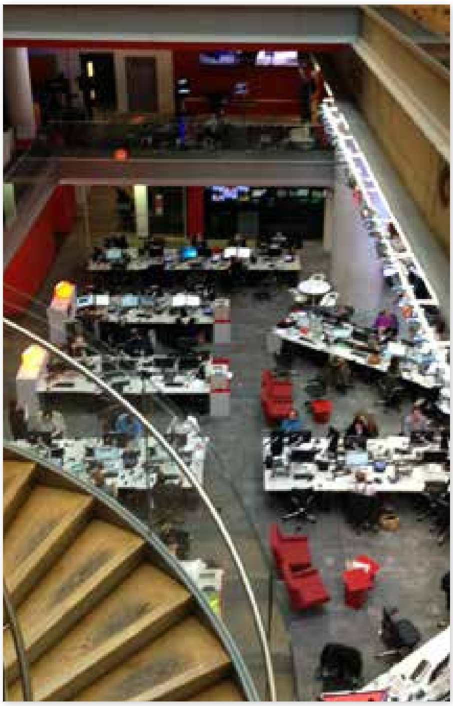
Not surprisingly, I got some very strange looks when walking into the new reception at Broadcasting House with a huge box which by then felt like it had multiplied its weight several times and a string of wires in my hand! After passing security and getting visitor passes we were taken through to the editorial suite of the BBC news studios. The TV22 was unboxed and everything was connected up and the set demonstrated to numerous BBC staff members, some of which were familiar faces from the television news. People came from far and wide to see the spectacle and amuse themselves that people actually watched something so small.

Throughout the time we had the TV22 running I had to hold two coaxial plugs face to face to make connection as I had not brought a coax coupler with me. You soon get finger fatigue doing that for extended periods. We were then rewarded with a tour of the BBC news studios where we may have been seen on the 1 o'clock news as we walked past the live 'On Air' news studios behind the presenter. Then through to some production galleries to see how it all works. It is so different to my previous visits to Television Centre. Then on for a look around the unseen areas of the original 1932 building where we were able to get out on the roof at the base of one of the original aerial masts behind the clock for a good view over the streets of London.

One area visited was a general gathering place where people could relax and chat under a sky filled with microphones hanging from the ceiling. I expect that is the quietest place in the building as no one dares to speak just in case they are being listened to!

The visit was rounded off by a late lunch in the BBC club.

Russell and myself in the Council chamber at Broadcasting house under the portrait of Sir John Reith.



View from above the news room looking across to where the weather presenter stands and automatic camera on mini railway.

Jim, Russell and myself at the base of the original aerial mast on the roof and behind the clock.

Russell, Jim and myself outside a communal area where no one talks.

Valve Audio – The Lumley 'Reference LR120' power amplifiers

By Martyn Bennett

In terms of my main collecting interests – 20's British battery sets & horn speakers – I was becoming 'the collector who has everything'. What to do?

Figure 1: A Lumley LR120 Mk2 Mono-block Valve Amplifier

Much to my wife's chagrin I decided to turn my attention to valve audio. I have been using a valve (tube) amplifier in my Hi-Fi system for the last 30 years and have been very happy with the overall sound. The amplifier in question is a Michaelson & Austin TVA-10 – one of the first British 'valve renaissance' amplifiers from the 70's (ref 1). As this amplifier had an usual circuit arrangement, I decided to find out more about valve amplifier designs from this period onwards.

Like 20's battery sets, valve Hi-Fi amplifiers generally have large & well-spaced components, which makes circuit tracing and maintenance & repair viable for me. They are certainly easier to find on the internet - and circuit information also. The one big advantage of valve audio is that many components are readily available and, of course, you can actually use them!

Lumley mono-blocks

One of my more interesting acquisitions was a pair of Lumley Reference LR120 mono-block power amplifiers, which I bought about 5 years ago. These are powerful amps with four KT88 output valves in paralleledpush-pull per channel (see specification table). This top-of-the-line pair date from 1995, when they had a list price of £3725 (including the optional pentode/triode mode switch)!!

Lumley Reference LR120 Specifications

Power Output:	120W per channel into 8 ohms (60W per channel in triode mode)
Sensitivity:	300mV
Input Impedance:	250k ohms
Overall Feedback:	18dB
Frequency Response/Bandwidth:	14Hz to 27kHz (-3dB)
Size:	175 x 432 x 280mm (7 x17 x11 inches)

Lumley Reference Review

The LR120s have a vice-like grip over the speakers. At low levels there was no loss of detail, and no loss of dynamic contrast. With lesser amps the extremes of the frequency spectrum seem to fall off at lower volume settings. Not so with the Lumleys. Similarly, at high levels there was no emphasis of sibilance, bass or graininess.
Head-bangers who listen loud may well find with these amps that there is more going on in the music than they had noticed before. So, too, would the low-level listener.
The range of contrasts and timbres which the amps can clarify is enormous and within a good hi-end system can really transport the listener to the recording environment. Power, tempered with subtlety, refinement and musicality best sum up the amp's capabilities.
- Hi-Fi News & Record Review, April 1993

The amplifiers were in excellent cosmetic condition - but faulty. The seller said, very openly, that he had them modified, to run in Class A for improved quality, and they overheated – so much so, that he had removed a pair of the four output valves! He recommended that they should be rewired back to their original Class AB configuration. A bonus was that the original instruction manual and brochure were included.

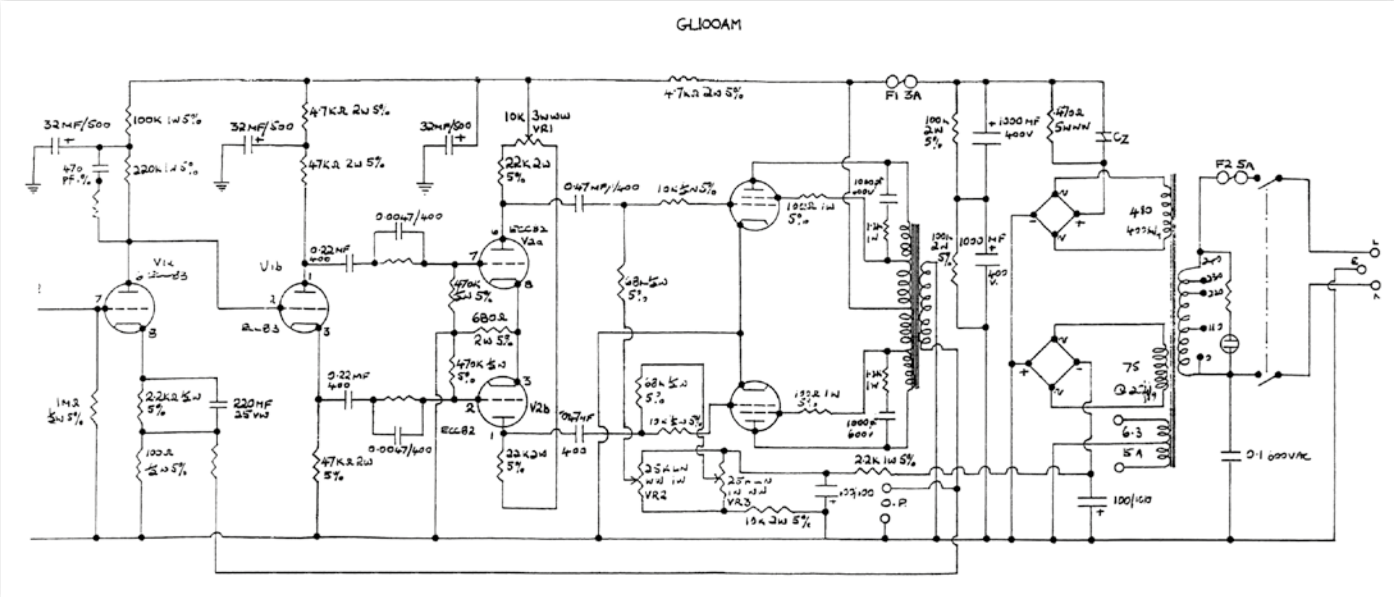


Figure 2: Circuit Diagram for Grant-Lumley GL-100 Mono-block

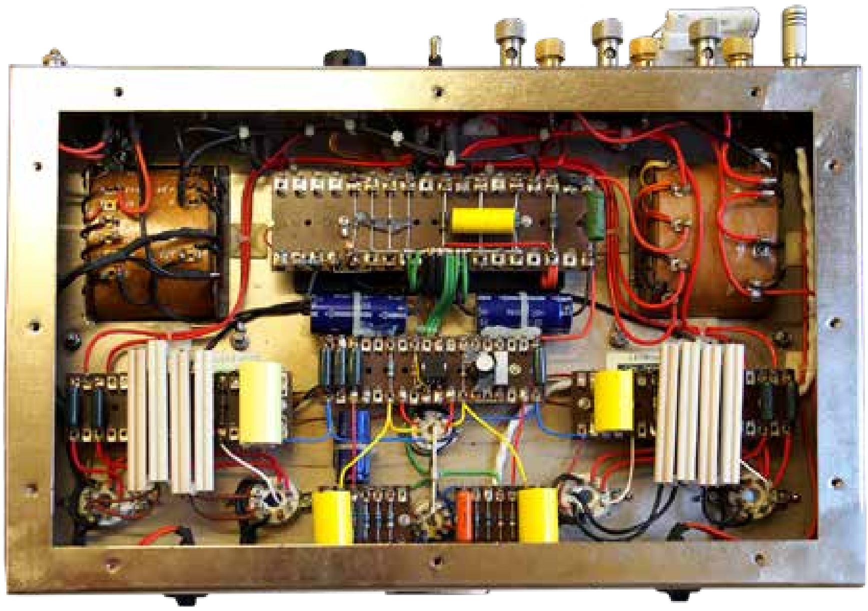


Figure 3: Under-chassis view of the modified Mk2 Lumley LR 120

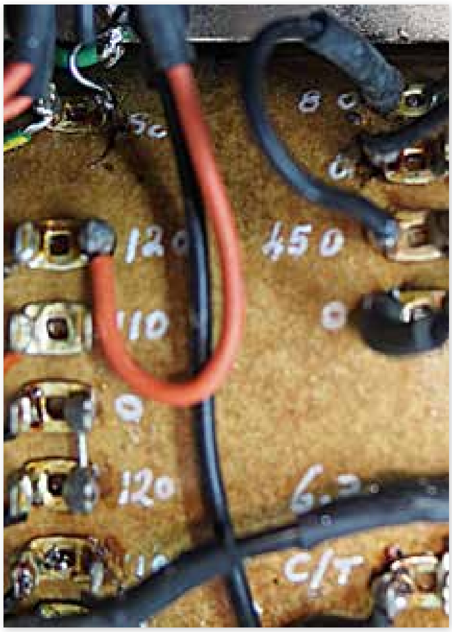


Figure 4: Close-up view of the modified mains transformer wiring

Table 1: Simplistic comparison of bias currents and valve dissipation

	HT (V)	Cathode (V)	Rk (Ohms)	Bias current (mA)	Valve Dissipation (W)
Leak TL/50 Plus	505	48	600	80	37
M-O Valve Co. ref. design	500	52	600	87	38
Lumley (modified)	480 (meas.)	50 (meas.)	550	95 (calc.)	39 (calc.)
Data Sheet Design Max	Va: 800 Vs:600				Wa + Ws: 40

First Steps

My restoration policy for valve Hi-Fi amplifiers is quite different from my policy for restoring 20's wireless sets, where I prioritize originality over functioning. In the case of these much more modern amplifiers I try to make them function and I give priority to safety, reliability and audio quality – in that order. I avoid making changes that can't be easily reversed. Before I do any work on a unit I try to gather as much information as I can – circuit diagrams, component layouts, technical reviews and web-forum comments.

On this pair, I immediately 'hit a brick wall'; I could not locate a circuit diagram or find any under-chassis pictures. My main challenge was to determine what the original circuit & layout looked like. I did however find out some background history of the manufacturer from one of the Forums, which helped.

It appears that Roy Grant and Ray Lumley produced audio amplifiers in the early '80s under the Grant-Lumley name – a notable one being the GL-100 mono-block. There was, apparently, a business breakup in the early 1980s and they subsequently designed and marketed audio equipment under their own names in the UK, throughout the 80s and 90s. The early amps from both Grant and Lumley were, allegedly, stellar performers in their day, giving "a 3D-like sound-stage and impressive midrange transparency", and they were compared favourably with the renowned Jadis amps.

Guided by this snippet of history, I searched for and found two related circuit diagrams on the Web – one for the aforementioned GL-100 (Fig 2), and another, similar circuit, for a Grant G60. Both circuits have the same topology as the famous, land-mark, Williamson Amplifier – except they use fixed bias for the output valves instead of cathode-bias and have Ultra-Linear configured pentode output valves. These two changes are more appropriate for high-power HiFi amplifiers.

Armed with this information I started to trace connections and get a first idea of the original circuit of the modified amplifiers. The under chassis view of one amplifier is shown in fig 3.

Figure 5: Under-chassis view of an essentially standard Mk1 Lumley LR120

The major changes that stood out were:

1. The Fixed Bias configuration for the output valves had been replaced by Cathode Bias – a 330 ohm and a 220 ohm resistor in series, per valve.
2. The 80v rms bias output on the mains transformer had been rewired to be in series with the 450 v rms HT output, with opposing polarity, to effectively reduce the HT output to 370v rms. (see the close-up view – fig 4)
3. The bias circuit had been disabled and some components removed.
4. Some of the chassis solder tags had residual solder where there had been a connection.

I also checked all the valves with my AVO valve tester; all were respectable.

The reclamation of the units didn't look too daunting, but I had a nagging worry about the bias circuit. The amplifier has a 5-way selector switch to route the bias monitoring connection to each of the four output valves, plus a disconnect position. In the initial LR-120 design each valve had its own bias-adjust preset. In the Mk 2 design, like mine, these are replaced by a single bias-adjust preset. An Instruction Manual Amendment describes the changed bias procedure, this is, to scan the valves to find the largest reading, and use this valve to set the 'bias' (45 mV) – rescanning and repeating if necessary.

The Instruction Manual Amendment reassures the customer that although the other valves may have a considerably lower bias reading "This is quite in order as the circuitry is self compensating". Is this just 'marketing blurb', or should it have cathode resistors – or even some exotic semiconductor servo? My initial thoughts were that it was a retrograde design step made purely to marginally simplify the biassing task.

I had no real incentive to examine the modified circuit and try to see why it overheated, but I made a quick comparison with the Leak TL/50 Plus which uses the same output valves and cathode-bias. I also have included the reference design values given in the M-O Valve Co. Ltd. Genalex KT88 data sheet (dated 1974). The more recent Svetlana ('S' logo) data sheet gives the same absolute voltage and dissipation figures as the Genalex sheets.

Simplistic comparison of bias currents and valve dissipation

Given that there will be some additional voltage drop across the output transformer, the calculations suggest the dissipation of each output valve is just within accepted limits. As the valves have their own cathode resistors, removing a pair of valves would not affect this – although it would obviously reduce the gross dissipation.

At that stage I decided I didn't have a clear plan for refurbishing the amplifiers and, as I was in no hurry to get them working, I put them on one side. Time for more learning and building up understanding!

The breakthroughs

A couple of years went by, during which time I kept my eye on ebay – for any LR120s being sold - and religiously checked out John Broskie's valve (tube) audio weblogs (ref 2); these 'blogs are tutorial in nature and give real insight into different valve circuit topologies – many devised by John Broskie himself. One of these 'blogs gave a glowing review [pun unintentional!] of a book on 'Power Supplies for Valve (Tube) Amplifiers' by a British author! (ref 3). Needless to say, I soon bought the book – it is bizarre that I only discovered a British book by looking at an American website.

The book did not disappoint. It is a designers bible, full of practical tips and insights. The chapter I really wanted to read was the short one on 'Valve Bias Supplies' - perhaps this would kick start the restoration? Merlin Blencowe supports the case for a bias winding within the HT transformer – like the LR120s - to give some compensation for mains variation and variation due to the changing load. He provides a simple, but refined, design, and a guide to selecting

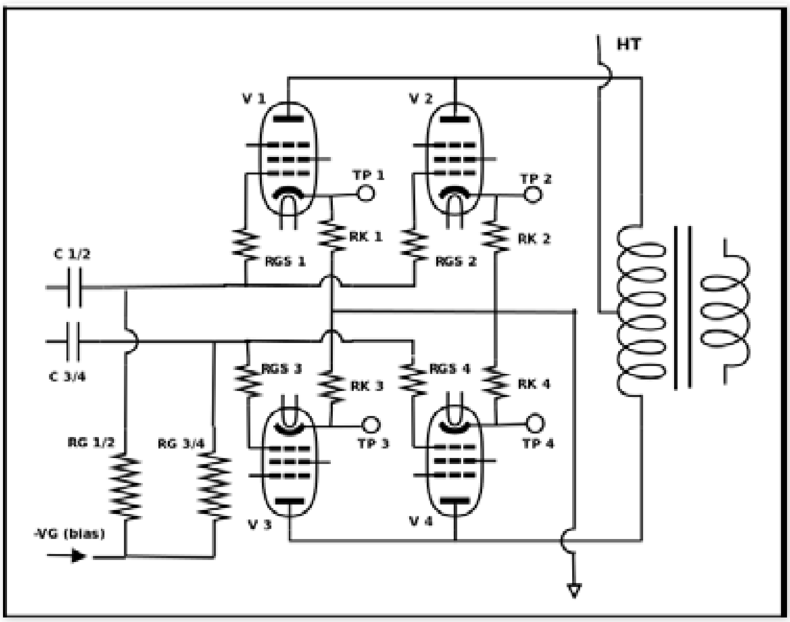


Figure 6: A skeleton circuit diagram for the deduced output stage

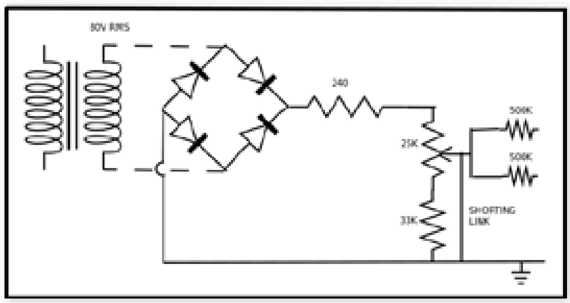


Figure 7: Remains of disconnected bias supply

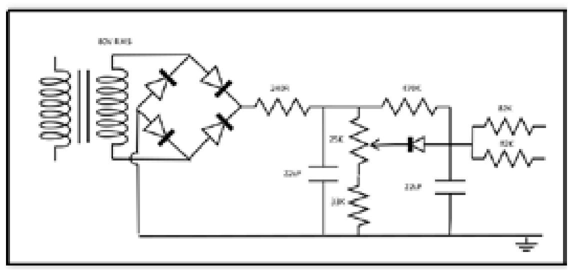


Figure 8: Reinstated bias supply

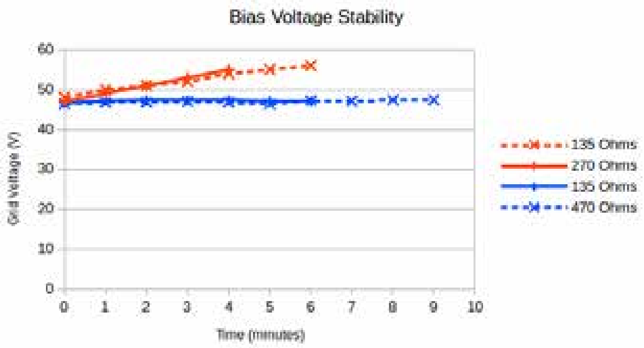


Figure 9: Runaway behaviour of ‘rogue’ valve c.f. ‘good’ valve (for different grid-leak resistances)

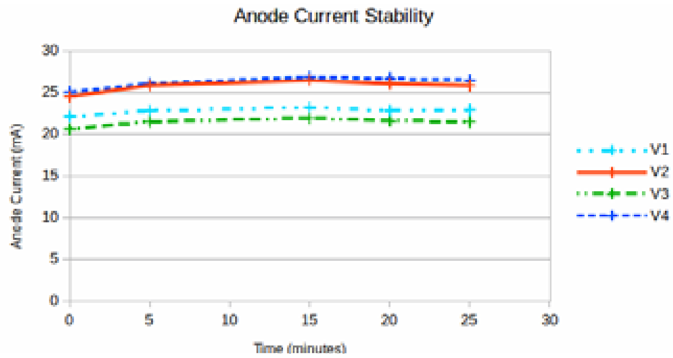


Figure 10: Bias current stability – second restored amplifier

component values. Just what I needed.

Spurred on by this, I carried out another thorough Google search. To my surprise I found on Mike Gilmour’s website (ref 4) an under-chassis photograph of an LR120 – the Mk1 version however. This is reproduced here, after being enhanced by some photo-processing (fig 5). Time to get restoring!

The restoration plan

The overall layout of the Mk1 and Mk2 amplifiers is, as expected, very similar; the two transformers and the power supply board are to the rear, and the amplifying circuit boards are at the front. The picture of the Mk1 amplifier (fig 5) indicates a strong similarity with the GL100 circuit (fig 2) - albeit with doubled-up output valves. Each output valve has its own bias circuit; the cathode-current sensing resistors can be seen at the ‘two o’clock position’ on the valve holders, and the four (square dark) bias pre-sets can be seen on the left & right adjacent tag-boards. As the valves are separately biassed there are 4 coupling capacitors – also mounted, on the two tag-boards.

Finally being able to see an under-chassis layout of the Mk1 amplifier, confirmed my evolving view that the Mk2 version didn’t have any novel bias-balancing circuit and just relied on matched & stable, sets of output valves! My interpretation of the output stage is shown in skeleton form (fig6).

A single coupling capacitor feeds the upper half of the push-pull circuit, which has a single grid-bias resistor; each of the parallel valves has its own grid-stopper resistor and also has its own cathode-current sampling resistor; the same applies to the lower half of the push-pull circuit. The Users Manual gives a voltage setting of 30mV up to 45mV for the bias (up to 65mV for the Mk1) which infers cathode resistors of 1 Ohm. The Manual describes these as “..serves to offer further protection to the surrounding circuitry in the event of a severe valve failure.” I managed to locate this type of resistor/fuse on the RS website.

A diagram of the remains of the bias supply, and a diagram of the bias circuit I decided to implement, are shown in (figs 7 & 8).

I planned to preserved the existing bias supply components, remove the immobilising shorting link and add two smoothing capacitors. I also planned to add two safety features described in ref. 3: The 470 K Ohms resistor ensures that the valves are given full negative bias voltage and cut-off, should the wiper loose contact. The added diode slows the discharge of the bias voltage after switch-off; this refinement protects the output valves should the amplifier be switched on again quickly, before the heaters have cooled down. The selection of the grid leak resistors is discussed later in this article.

The other area that had been modified, it seems, was the ground connections. My web search also yielded a forum note on, what appears to be, the amplifiers I now own!

“Lumley reference 120 monoblocks were heavy on valves(6550) and suffered from mains hum due to multiple chassis earth points. Owners were advised to disconnect the mains earth and rely on the connection to the preamp - not satisfactory. Mine now run KT 88’s in class A at about 200V less than their max, the earthing is single point - no hum and safe! ….”

So this explains the residual solder on some chassis earth Tags. Sure enough some extra circuit-earth wires had been connected to the existing ‘bus bar’ (see also the Mk1 picture), but this also had been ‘floated’ off chassis earth by a 10 Ohm resistor - a technique I had come across elsewhere. I was happy to leave this earth rewiring in place - at least initially. The main impact for me was that the current-sampling resistors now needed to be returned to the circuit earth – not to local chassis points, as originally built. I decided to mount them on the adjacent tag boards for easy wiring.

Pre-restoration valve tests

I was then nearly ready to get out the soldering iron. It seemed sensible to leave one amplifier untouched, as a reference, and rework and test just one at a time. Before I started dismembering an amplifier I thought I would measure some voltages to get better acquainted with the layout. I picked the amplifier which had the four similar valves; they were all Svetlana ‘S’ logo valves with one of them having a ‘jazzy’ distributors sticker on the base.

For the tests I ‘shorted’ the input with a small resistance and attached a dummy load resistor. Instead of a speaker I used a variac to increase the supply voltage in stages, measuring the voltage across each cathode resistor. When the supply voltage was raised to 230V the voltage across one of the cathode resistors started to steadily creep up! Test stopped. My mind turned to checking the grid-bias resistors; because of the single bias set up, a grid bias resistor serves two (paralleled) valves. The resistors were 470 K ohms, whereas the Genalex data sheet gives 270 K ohms as the maximum for a single valve at this dissipation level. As the other valves seemed OK, I soldered a 680 K ohm resistor in parallel across one of the grid-bias resistors – to give about 270 K ohms.

I repeated the check for 230 V supply with the other output valves removed; this did not solve the problem so I put a 270 K ohm resistor in parallel to achieve the Genalex specified per-valve bias-resistor; still no success! As a

Table 2: Valve matching and pairings – first restored amplifier

Valve Ref.	Anode Current (mA)	Mutual Conductance (mA/V)	Position in Amplifier (1st try)	Position in Amplifier (2nd try)
AVO Manual data	57	8	-	-
V1(a)	59	8	spare	LH(a)
V2(a)	67	8.5	LH(a)	spare
V4(a)	64	8	RH(a)	RH(a)
V1(b)	68	8	RH(a)	RH(a)
V4(b)	65	7.5	LH(b)	LH(b)

Table 3: Valve matching and pairings – second restored amplifier

Valve Ref.	Grid Volts	Anode Current (mA)	Mutual Conductance (mA/V)	Position in Amplifier
AVO Manual data	-20	57	8	-
Valve carton data	-	62	7.4	-
V1	-22	58	7	LH(a)
V2	-22	57	7	LH(b)
V3	-22	55	7	RH(a)
V4	-22	56	7	RH(b)
V2(a) spare	-22	56	7	-

double check, to see if the coupling capacitor was leaking, I repeated the test with the single output valve moved to the other half of the push-pull circuit (still with a 470 K ohms grid-bias resistor). The results were similar.

The final tests I did were to replace this, apparently rogue, valve (in fact the one with the resellers label!) with one of the others 'good' ones and repeat the tests. The main results are shown in fig. 9 (the 'rogue' valve is shown in red, and a 'good' valve in blue). I don't exactly recall the sequence of events, but I determined that the other two Svetlana 'S'-logo valves from the other amplifier were OK - judged by these tests. That gave me 5 valves to choose from for refurbishing this amplifier.

Restoration of the first mono-block

After all the researching and testing, the rebuild was comparatively simple. I reconnected the mains transformer wiring – leaving the input wiring to the 240 V terminals - and resurrected the bias supply & current sampling circuits. I wired in 150 K Ohm grid-leak resistors. Having discovered a 'rogue' valve that showed output current 'run away' at an anode voltage of about 400 V, I was going to be particularly vigilant testing at the now raised anode voltage of about 600V.

I powered the amplifier using a variac, with the input valves plugged in, but no output valves. For 230 V a.c. the HT voltage was 600 V and the bias voltage could be adjusted over a range of about -90 V to -110 V. So far so good.

The 5 Svetlana valves I had available were retested using my AVO valve Tester; the tests used the settings given in the AVO Valve Manual (Vh 6.3, Va 250, Vs 250,Vg -20 & Ia 57 mA). The results and my selected placements are shown in table 2.

I selected what appeared to be the best pairings and cautiously raised the mains voltage , sampling each valve and adjusting the bias; the bias currents, in mA, were (25, 11, 11, 11). I swapped the first valve for the spare one and readjusted the bias; the bias currents, in mA, were now (21, 26, 27, 32) – somewhat less spread. I turned off the amplifier, moved the mode switch to 'triode mode' and checked the bias readings; they were virtually unchanged – (20, 26, 26, 30). I monitored the bias for about half an hour, with no evidence of current runaway. Relief!

For the first time I connected the monoblock into my hi-fi and played some jazz CDs, checking the bias continually. The bias was very stable. Even more rewardingly, it sounded good and was silent, without any trace of hum or interference noise. Great!

Restoration of the second mono-block

The restoration of the second mono-block now looked to be straightforward, but the question to be answered was: what valves to use? Because of the simplistic and marginal biassing arrangement it was clear to me that a set of very well matched and stable valves were essential. I decided to buy a set of, so-called, 'Factory Platinum Matched' valves. It is claimed that these valves are pre-selected from a new production batch, tested and then operated for 24 Hrs. They are then retested and the most stable ones grouped into matched sets. I also wanted to buy from a supplier who gave the impression of having some technical competence. This proved not to easy, and I ended up buying a matched-quad of Svetlana 'C-logo' from the USA. The measurements of the set of valves is shown in the table 3.

You can see the valves are very well matched, both for anode current and mutual conductance. The cartons were all marked with the same values each for anode current and mutual conductance, but didn't give the test voltages. For the AVO manual settings the valves drew more current than the KT88s of the day and I found that an increase of bias from -20 V to -22 V matched the figure in the AVO manual.

I completed the rewiring of the second amplifier copying the first one; I did however fit 82 K Ohm grid leak resistors instead of the 150 K Ohm one in the first amplifier. I did this to give more insurance against current runaway, with the intention of doing the same to the first amplifier later. I recognized that substituting lower value resistors would lower the feedback loop-gain and raise the low-frequency roll-off frequency, but this should not impair stability.

With a dummy load fitted I gradually raised the supply voltage to 230 V and monitored and adjusted the bias. All was well and I checked the bias stability over a period of about 30 minutes. The Bias current stability is shown in fig 10.

The last leg

Now for the reward for these efforts - I hope. I replaced the amplifier in my main HiFi system with the two mono-blocks, making sure I had easy access to the bias adjusters. I followed the instruction manual and carried out the ritual 'stand-by' and HT power on sequence. The bias readings were as expected and were stable and there were no extraneous noises! I listened to four modern jazz CDs, and the music was fine. The bias readings at the end of the session were virtually unchanged.

The size, and weight, of the amplifiers were a problem and my wife suggested I should replace my narrow HiFi stand with a wider 'audio-visual' stand. I found a nice second-hand one locally (via Ebay) and with an added plank of MDF, to support the glass shelf, the new system was up and running (fig. 11). I have been using it ever since.

Reflections

As a relative newcomer to valve audio restoration I reflected on the lessons I learnt from this project. The usual one for me is how I, optimistically, expect the restoration to be much easier than it turns out – certainly the case for this restoration. But, the outstanding lesson for me was the variability in the quality of output valves. In particular, passing test on the esteemed AVO valve tester being a necessary, not sufficient, test for satisfactory operation in the amplifier. Also, the importance of buying the higher quality examples of the production batches – especially true for amplifiers which operate the valves at the edge of their capability.

Figure 11: Restored Lumley LR120s in-situ

References

1 'Audio Audio', Jonathan Hill, Sunrise Press, ISBN 0 9511448 55 - pp 10
2 Tube CAD Journal www.tubecad.com
3 'Power Supplies for Valve (Tube) Amplifiers', Merlin Blencowe, ISBN 9780956154514
4 Mike's Page, www.lurcher.org/ukra/mike_g/mike_g.html

The View Master kit television

By Roger Grant

A single channel home built TV from around 1950, this kit set could easily be mistaken for something commercially made, the cabinet certainly is and it's quality as good as any branded set, a bit more up-market and refined than the home made sets from war surplus parts and definitely a lot more acceptable in the front parlour.

The set.

Back in it's box.

Marketed by the Lasky's and Premier Radio chains and adverts also appear in several other war surplus outlets, a bit more appealing to the higher earner with it's elegant cabinet, or novices perhaps as it appears to require a little less skill to build with its full instructions and prefabricated parts.

The View Master was available in most regions, the advert states that it can be built from step-by-step easy to follow instructions, can be aligned without a signal generator and comes with several options on a quality veneered cabinet, several were available to suit the 9" or 12" tube versions of this kit set, the table model, the console model, ready made, or flat pack, as depicted by the man carrying a flat pack in the adverts.

It looks like the chassis and mechanical parts came pre-folded and punched, but alternatively, for five shillings, just the set of assembly instructions with a building and operation booklet could be purchased separately, these instructions do give full drilling and folding details for all the metal work including the tube housing furniture for the more skilled constructor, or anyone else who would like to go it alone.

The set in this article has the ready made table model cabinet with rounded top edges and definitely not a flat pack, it appears to be in reasonably good condition, although it has suffered from a few "Auction" scratches and dings. The top surface of the chassis is a little rusty, but not enough to require any attention and it would be very desirable to keep the set as near as original and "as found" as possible. The underside of this tinplate chassis is still quite bright and a lot of the mica feed through decoupling capacitors have been bridged with more modern types, the electrolytics look original and there's a date stamp on one of them, Sept 49 so it looks like this kit set was probably sold some time during 1950.

The circuit

The circuit diagram shows a fairly simple and straightforward single channel TRF set full of "Red Devils" as the EF50 valve was affectionately known, but there are one or two features that make it a bit more interesting, like the Thyratron time base oscillators, the extensive use of metal rectifiers, using very basic circuitry and although a simple set, both the sound and vision receivers have interference suppressor circuits included, mainly aimed at car ignition interference, a big problem for both radio and television in the 1950's.

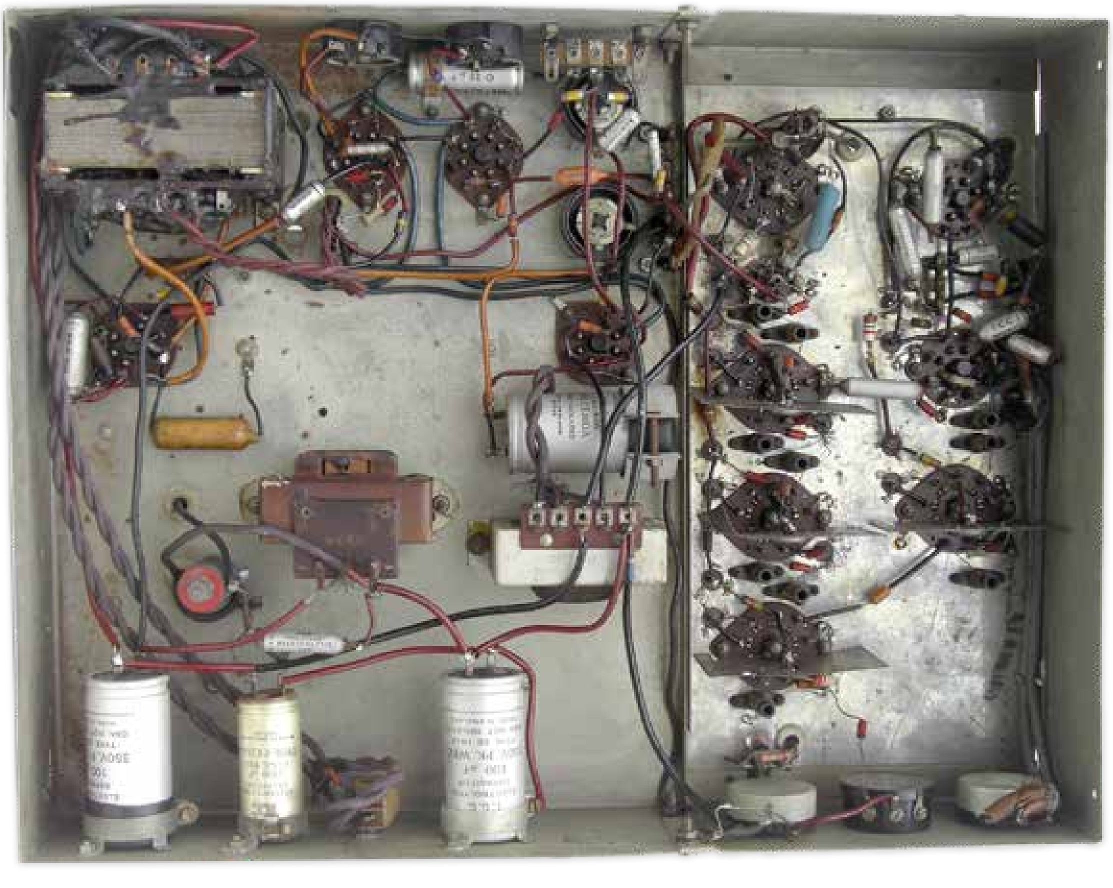
The sound and vision strips share the first RF amplifier V1 an EF50, saving a sound valve, the vision strip follows with two more amplifiers V2 & 3 also EF50's, followed by the detector and sync separator V4 an EB91 double diode and the video amp V5 another EF50, finally the white spot suppressor diode MR5 a Westinghouse WX3.

The sound channel has a single RF amplifier V6 an EF50, followed by V7 the sound detector and audio amp a double diode triode an EBC33, followed by the interference or spike suppressor MR1 a WX6, then the sound output valve V8 a 6P25.

The time bases are a little unusual using thyratrons as relaxation oscillators, these are the 6K25 gas filled discharge valves, a very simple free running saw tooth generator triggered by the sync pulses applied directly to the grids. The frame oscillator drives a 6P25 output valve and the line oscillator driving a 6P28 output valve, also generating the 6500 volts EHT supply via the EHT transformer and a metal rectifier MR3, a 36-EHT-100.

The efficiency diode, yet another metal rectifier MR2 a 14-D-36, also supplying boost volts, usually used to drive the CRT A1 (grid 2), but this set uses a 9" CRM-92A tube, a triode, so not used in this set.

Top Chassis



Bottom Chassis

The HT supply is as simple as it could be, just rectified AC mains through a half wave metal rectifier MR4 a 14-A-46 and the usual choke and capacitor smoothing circuit. The HT return is via R70 a 15 Ohm resistor to mains neutral, decoupled by C55 a whopping 2500mfd low voltage smoothing capacitor, quite a high value for the early 1950's, this supplies the -3 volts biasing for V5 the video amplifier, allowing maximum gain from its EF50 saving another valve.

All of the valve heaters are 6.3 volts, wired in parallel and supplied by a mains transformer with a separate winding for the CRT heater of 2 volts.

The last part of the power supply is a neon, its sole purpose is to warn of a mains plug reversal and a live chassis, it only works if you connect the earth flying lead to a good earth, otherwise it tells lies, not a good idea, and the only reason why the set has an earth connection.

Twelve valves in all, five metal rectifiers and a neon.

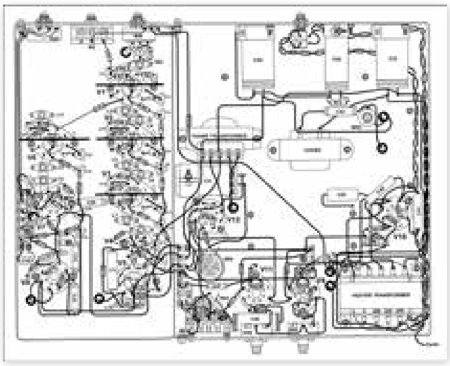
Getting it working

During the usual cold checks, I noticed that a replacement EHT smoothing capacitor had been fitted and was dangerously dangling in space along with the end of the EHT pencil rectifier, I checked the state of the original disconnected "Visconol" EHT smoothing capacitor and it had about a 500k leak, removing this I drilled out its innards up through the bottom leaving its case and base intact, not finding a capacitor that would fit inside, I just Araldited a 2BA bolt into the base then refitted and used this original as an anchor point for the new capacitor and EHT rectifier.

Under the chassis, R22 two 12k resistors in parallel in the video amp anode load circuit were cooked up and very black, still in parallel they read around 4k on the AVO, these at one time had deposited heavy black waxy smoke residue all over the video amp valve base and surrounding chassis, I looked around for a reason for this cook-up but everything checked ok, I scrubbed off the waxy residue with a stiff brush and solvent and replaced these two resistors with a single 5k6 2 watt resistor making note of this for further investigation on power up. There was evidence of other HT feed resistors further along the HT line that had got hot and caused some staining of the nearby tinplate, these had already been replaced by a previous repairer.

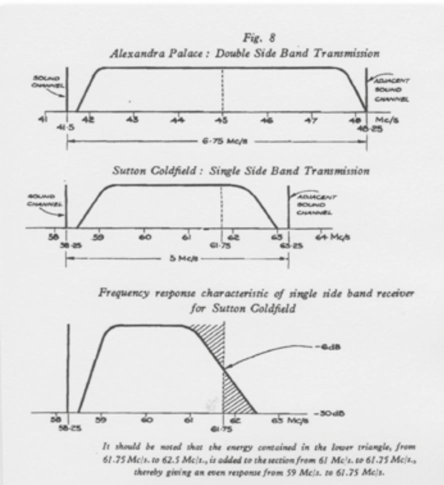
Now tidied up and fully checked for short circuits and all the main capacitors checked for bulges and electrical leaks, I applied some power, this set having a live chassis makes a mains isolating transformer essential. The valve heaters lit up and after a minute or so the audio stage crackled into life with a gentle purr in the background, a minute or two more and a raster appeared on the tube, advancing the brightness and contrast controls proved the tube to be quite bright and the raster appeared in reasonable focus, applying a signal from my test card generator I could now hear a faint 400 c/s signal from the speaker, this signal also appeared on the tube as a half dozen or so horizontal bars but no test card, a waggle of the EF50's in their sockets produced a lot of flashing on the screen and heavy crackling and rasping in the speaker but nothing else, during this operation the gentle purr from the audio stage faded to nothing and I then noticed that the 6P25 sound output valve heater no longer glowing, a waggle of this valve in its socket made no difference. As the heaters in this set are transformer driven and the rest of the valves appeared ok, I tried it on the valve tester and its output was well within spec, a run around with the AVO proved 6.3 volts on both heater pins of this valve, so the ground is missing, pin 2 is grounded via a solder tag under the valve holder retaining nut and now open circuit, this was remedied by a rotation of the screw and on power up the heater had returned.

I suspected that as this ground point had gone open circuit all of the others could do the same, some including the de-coupler and screening grounds and could explain the strange response to the input signal. This prompted a small mod as there's nothing worse than trying to work around intermittences. As the underside of the tinplate chassis is still quite bright, I soldered a piece of 22swg tinned copper wire to the chassis under the solder tag overhang and folded it over and soldered it to the solder tag, I did this to all of them there are about 8 or 9 of these. The valves were still very intermittent in their sockets and the whole stage seemed very noisy, I had already cleaned all of the valve base pins and spigots prior to the power-up so a much closer inspection was next. With the valves removed it was easy to see that some of the valve holder contacts were a bit wide and misplaced, these are only cheap paxolin valve holders and won't take a lot of valve changing, all of the offending contacts were bent staight and re-tensioned, this was easily done on these skeleton valve holders where the contacts are reasonably accessible, during this operation I noticed a bit of movement on the valve screening plates, these were held in place and grounded at three points, both ends of the plates were soldered to a second set of solder tags under the valve holder retaining nuts and the middle of the screen soldered



Component location from the assembly instructions.

The assembly instructions.



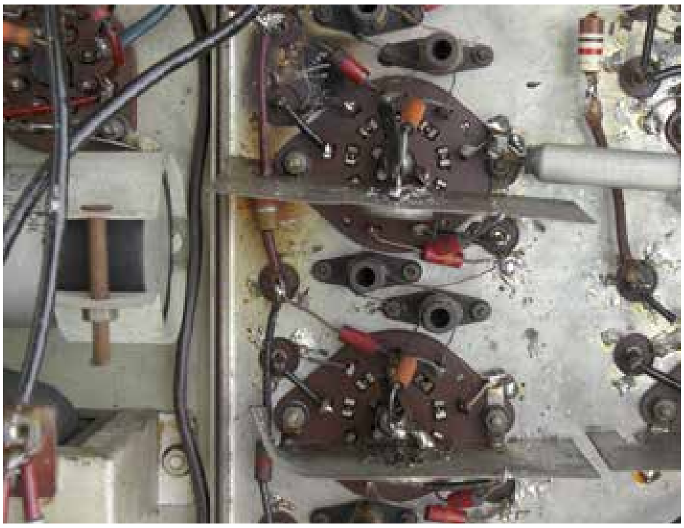
DSB/SSB diagram from the booklet.

The Lasky's Ad from Practical Television March 1952.

The Man with the flat pack.

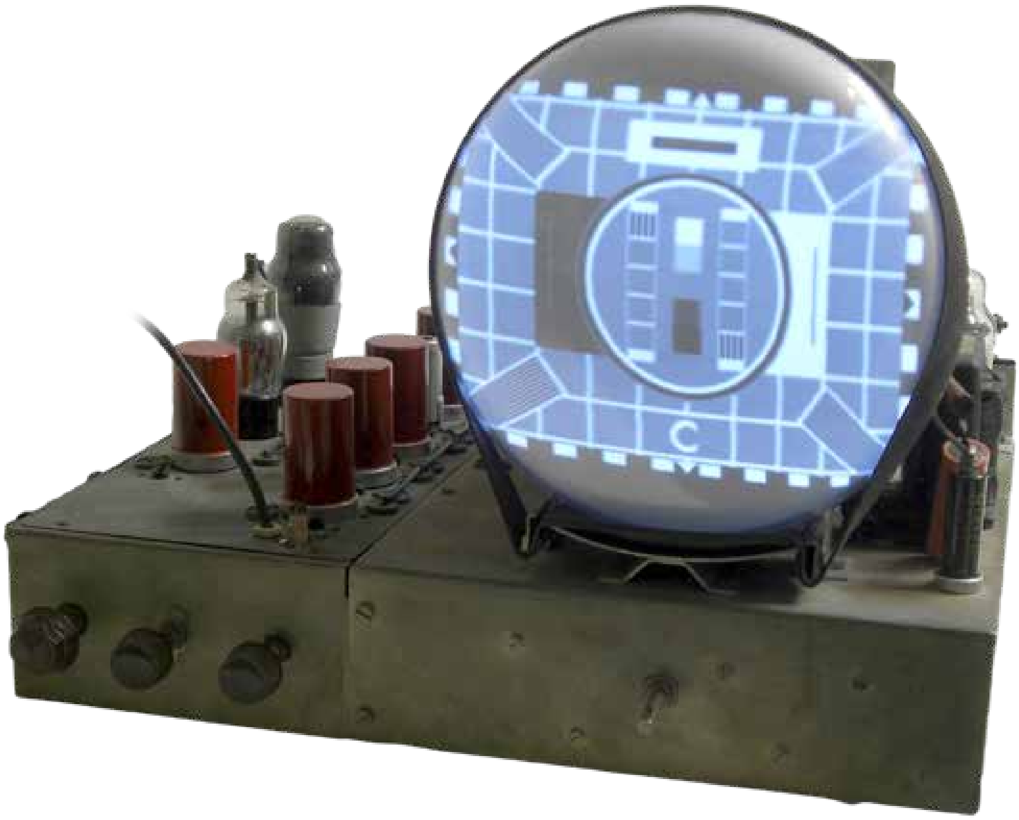
The smoothing block dates the set.

The focus, picture centring and triode electron gun.



The Valve holder earth points.

The neon on the mains input panel.



Fix'd!

to the spigot earthing tag in the middle of the valve base, on all four of the screening plates there were at least one of these ground point solder joints broken away and open circuit, these were re-soldered. On power up the vision strip was now much improved and no longer appeared intermittent, this made no difference to the response of the sound and vision strips.

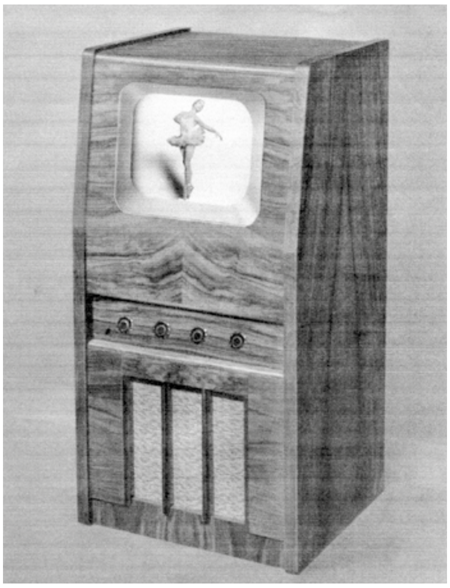
At this point and before I go any further was a good time to run around with the AVO checking the voltages on all of the valves, especially V5 the video amp in view of its previous anode load resistor cook up and all of the voltages were about what I'd expect, I left the set running for ten minutes or so and checked for anything getting hot and all was well. The next step was to connect up to the signal generator and sweep from 30 - 100 Mc/s to check that this was definitely an Alexandra palace set, as this sets sound and vision channels both responded to around 41 Mc/s I had assumed that it was and the signal generator proved it to be deaf to any other frequency, this also confirmed my suspicions that this set has had its coils twiddled.

Still on the signal generator I tweaked the three sound coils to 41.5 Mc/s and they seemed to tune in ok, tweaking the vision coils to 45 Mc/s proved to be a lot more difficult, the vision strip seemed to drift about all over the place, but

I did get the vision strip in the ball park, I then reconnected to the test card generator and after several more passes though tweaking the vision strip I had a reasonable picture behind a background of noise but with lots of gain, the contrast pot (RF gain) spent most of its time at minimum, the vision strip seemed to be over sensitive to hand capacity especially near the replacement decoupling capacitors strapped across the original mica feed through capacitors still in place, this seemed to vary the gain of the stage and made tuning very interactive and difficult.

These original feed through mica capacitors (500pf) even after fifty or more years are usually very reliable and I questioned the necessity to replace them, the replacements were modern 2200pf types soldered across the originals and in close proximity to the tuning coils, I suspected that these may be the cause of this interference. Removing some of these I checked the capacity of the original feed throughs and all of the ones tested were ok, correct capacity and no leak, as I expected, with the replacements removed I powered up again and found a lot of improvement, but had not cured the whole problem, with this I removed the rest one by one checking the original capacitor as I went and every one removed seemed to reduce the noise and over sensitivity to this hand capacity, this stage is now much more manageable and stable.

At this point I started the re-alignment again from square one, this time I intended using the specified alignment procedure, for this



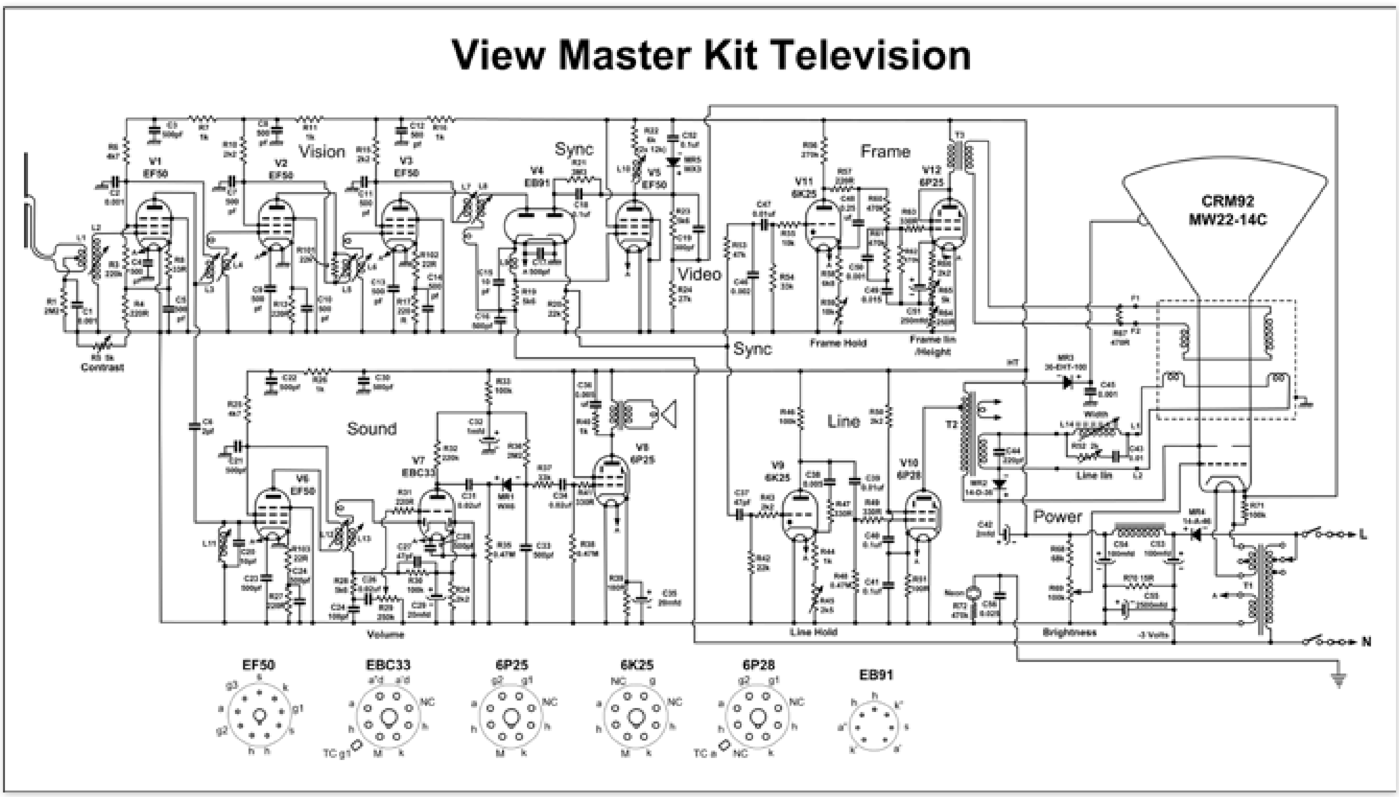
The console model from the booklet

The console model from the booklet

I consulted the "Building and Operation" booklet that I had downloaded off of the internet as the set came with no manual or circuit diagram, unfortunately this booklet is for the Sutton Coldfield region on channel 4, an SSB station, its receiver circuits were a lot different from my London set, being SSB it had four extra rejection coils and the sound inductively coupled to V1 instead of capacity coupled as in my set.

Before going any further I decided to re-draw the circuit diagram, so the drawing I'm working from is exactly the same as the set and eliminating any confusion, using the Sutton Coldfield version as a base as the rest of this sets circuit is the same as the booklet, I only needed to make drawing changes to the tuning coils.

I then re-aligned the set as before from guess work as TRF should be reasonably straightforward, I re-peaked the sound coils



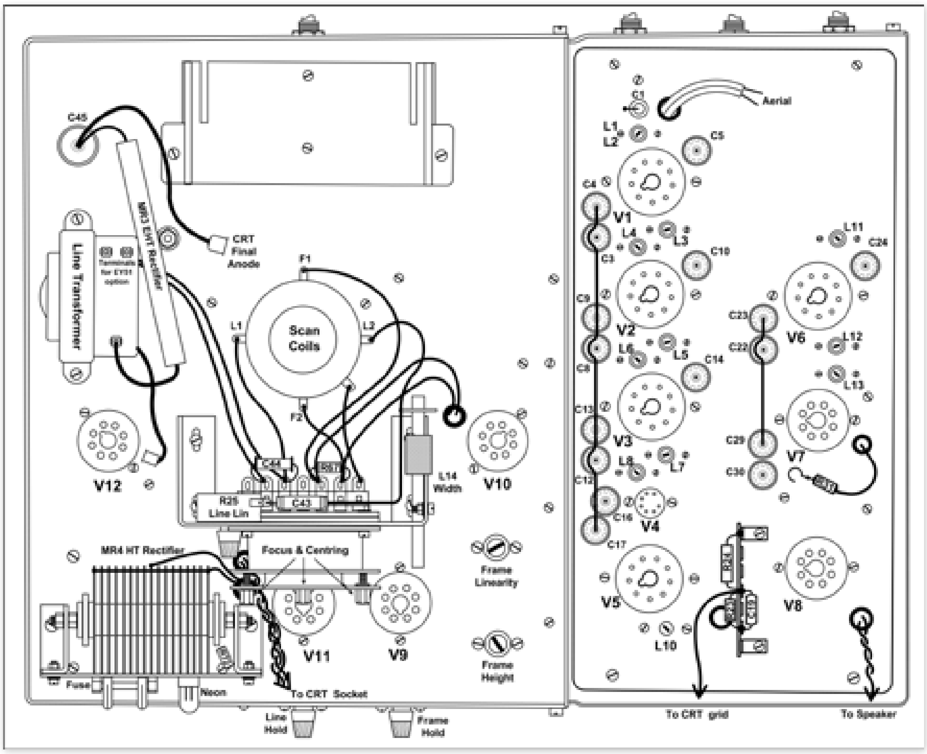
The View Master Circuit Diagram

Inside the cabinet

first, then the vision strip for maximum gain, then tweaked the shared first RF stage V1 for best sound/vision compromise then staggered the vision coils for best definition, this proved again to be a little more difficult than expected and at the end of several passes I found that the sound was a little low in gain and the vision a bit high gain, too high, the picture is still a little over contrasted with the contrast pot at minimum, reducing the vision gain by increasing the tuning stagger didn't help much and attenuating the input signal for a better contrast further reduced the sound and caused the line syncs to start pulling, at this point I took some time out to study the circuit a little more closely looking for a reason for this extra gain.

Starting back with V5 the video amp, as it had obviously had problems in the past, I re-checked the components and for any leakage especially the paxolin valve base and all was well. With nothing obviously wrong I then went back to the beginning and re-started with V1.

The screen grid voltage on V1 was a little high, just a few volts, but warranted checking the screen grid potential divider, the earthy end is grounded via the cathode bias resistor chain R3, R4 and R5 the gain control, this provides a positive bias to the cathode of V1 making the control grid more negative with respect to this, reducing the stage gain, the first resistor in the grounding half of the chain, R3 a 220k, seemed a good candidate, lifting one end and checking with the AVO proved it to be completely open circuit, the other resistors



Top chassis Component location

checked ok and on replacement of R3 and power up, the characteristics of the vision strip had now changed completely. A good contrast range now in the middle of the control and reducing the video to cut off completely at the bottom end, a bit more like it should be, with the contrast control now set at around its mid point also increased the level of the sound solving both problems at same time.

With the vision strip now working correctly and making a more successful pass through an alignment, I could make a better assessment of the state of the tube, a 9" CRM-92A, a triode tube.

While I had a good level of brightness the focus could be a bit sharper and the peak whites tended to get a bit woolly with the level of beam current, this indicating that the tube may be a bit gassy.

The focus adjustment, like the rest of this set is a very simple mechanical arrangement, a ring magnet around the neck of the tube with a flanged sleeve through it, this sleeve is attached by three captured hexagon headed brass threaded rods 120 degrees apart, collectively adjusting the three screws equally adjusts the gap between the flange and the ring magnet adjusting the focus, adjusting the screws individually unevenly varies the gap width adjusting the picture centring. This made setting up the focus a tad difficult, half a turn on each screw at a time, after several passes I appear to have made little or no improvement and suspect that the adjustments were back where I started. The rest of the picture controls all worked well and had a good range of adjustment, setting up the size and linearity in frame and line very easily achieved, the very simple sync circuits worked very well with a good solid lock in both line and frame with no requirement to make any adjustments at all.

The final problem was the picture was still suffering from a little background noise, this appeared to be coming from the aerial input, this is a balanced input and is via about 2 feet of twin feeder with a relatively modern coax aerial isolator soldered to the end (c.1960-70's), I assume fitted by the previous repairer, the aerial input feeder is isolated from the chassis via a double layer of insulating paper on the aerial coil input winding, the centre tap of which is static grounded via 0.01mfd cap and 2 meg resistor to chassis, removing the modern isolator and fitting a Balun aerial matching transformer made no difference and after trying several interfacing methods using various other matching transformers I found the only way to eliminate this background noise was to ground the output coax screen of the standards converter to the sets chassis via a 500pf capacitor, with everything these days powered by very radio noisy switch mode power supplies and digital devices radiating anything from DC to light blue I decided I was fighting a loosing battle and

The chassis

connected a piece of coax to the aerial input tags feeding the isolated input winding, this coax screen grounded to chassis via the original 0.01 cap and 2 meg resistor close to the input winding, the centre tap left open circuit, this solved the problem completely.

The set now up and running, so just for good measure as I had now finished fault finding on this set, I ran though a final vision alignment adjusting the vision coil stagger and tuning for best definition, I managed to define the first three of the five test grids on test card "C" and concluded that was the best I was going to get with the tube a bit gassy, despite this, with good adjustment of the brightness and contrast, a very watchable bright and well contrasted picture was easily achievable, the alignment adjustments then locked by a little soft wax melted into the top of the coils onto iron dust slugs.

The Cabinet

The cabinet is the usual thin plywood over a front and rear frame with the rolled edges supported with shaped blocks glued on the inside, the front and base are made from a more substantial 3/8" ply. On close inspection the high gloss lacquered finish has quite a number of small digs and scratches and unfortunately the lacquer has started to craze and crack, but it has retained its high gloss finish and at a more normal viewing distance generally looks quite good. The end grain of the plywood front in the speaker fret and tube aperture is filled and painted cream this is still in good condition. The rubber tube mask has started to turn into toffee and sags a bit at the top, the outer surface is hard and has some deep cracks revealing the softer rubber interior, a bit like a boiled sweet that's chewy in the middle, it's worse at the back of the mask than the front as the front had been painted from manufacture and appears to have deteriorated a bit less.

The set has a home made back and I wondered whether the set ever had one originally as the aerial input is a fly lead rather than a properly fitted socket, there's also no evidence of the chassis ever being fixed to the cabinet.

Despite the minor signs of age the set generally is quite a nice example of one of these kits and works very well and as the advert says "As good as any commercial set".

The "Building and Operating" booklet for this set is quite detailed complete with a circuit diagram, component lists and the finer construction details, and of course, the instructions of how to align the set with or without a signal generator, 32 pages in all with a good beginners tutorial of how a television works, transmitter and receiver. There are explanations of circuit techniques, interference suppression, band width, single side band and even covers aerial installation information. I found this quite interesting reading.

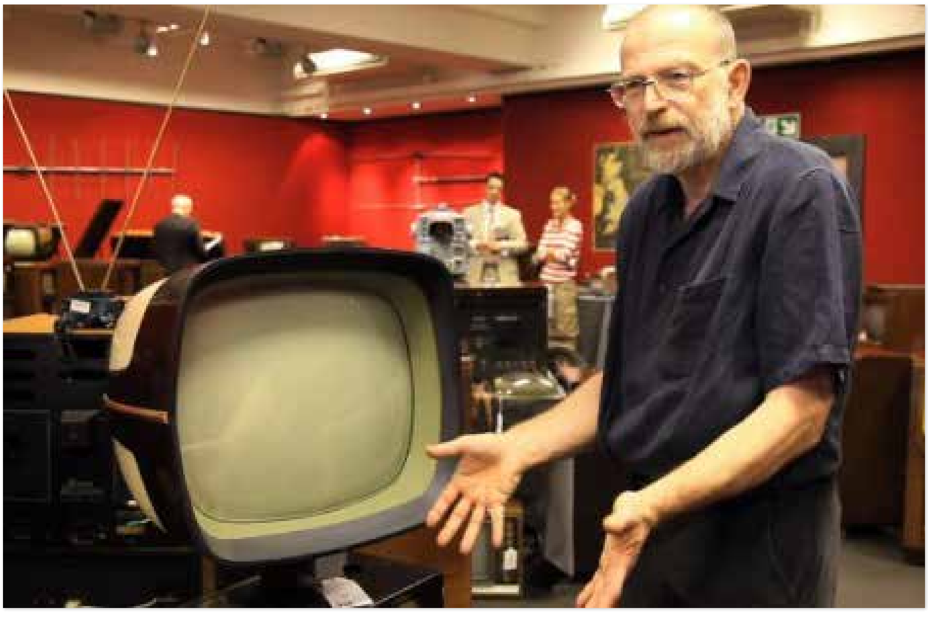
The yellow envelope illustrated only contained the eight wiring and component assembly drawings for the London set but nothing else, I could only find a pdf copy of and downloaded the Sutton Coldfield version of this set from the internet and it can be found on:- www.g4dmp/viewmaster.pdf

Showing an old favourite

Michael Bennett-Levy

An appreciation from Malcolm Baird.

October 1946 - September 2016



Michael Bennett-Levy, who passed away on 28 September 2016, was a leading collector of early technology items including television sets. His illustrated books TV is King and Historic Televisions and Video recorders are classics. His focus was on the external design of television sets, rather than the electronic circuitry. Many of the sets collected by Michael can be seen in museums such as the National Museum of Scotland in Edinburgh and the MZTV Museum in Toronto.

When I first met Michael in 1994 at his large house near Edinburgh, I was infected by his enthusiasm for television history. This became almost a full time job for me after I retired from chemical engineering in 2000. Over the last few years Michael had some major health problems which he faced with courage and his characteristic sense of humour. His loss will be greatly felt by the television history community.

Audiojumble1st October 2016 photos by Carl Glover & Mike Barker


DECCA
LEAK
LEAK
Stereo 20 power
£650.00 595-


VOIGT
CORNER HORN
1937


VOLUME
FILTER
FUNCTION
TREBLE
BASS
RECORD
AUX
BALANCE
FOCUS
STEREO-MONO
Expert Gramophones Ltd
London
AUDIORAMA

Letters

Dear Editor

Reading Graham Dawson's article on record auto changers in the Autumn 2016 issue of the bulletin, brings to mind a fix I came across in the early 1980's.

There was a problem with the rubber idlers in the early video machines, rewind, fast forward and take-up would slip to the point of failure, fitting a new idler would sometimes only last for 6 months or so, cleaning and roughing the rubber tyre for a much shorter period, this made a lasting repair impossible. I found the answer when I visited my local car parts shop, the owner Bill who I knew quite well had his video machine on the counter in bits as the rewind had failed, I told him that the rubber idler was slipping and I would get him a new one, he said I'll soon fix that and reached for a Holts aerosol spray for treating car fan belts, I told him I didn't think it would work, but he insisted so I removed the idler and he gave it a short squirt, on re-assembly I checked the rewind torque with my fingers and there was more than expected from a new idler, with this I purchased a tin.

I would squirt the spray into a tub and collect the liquid, I would use this sparingly with an artists paint brush on idlers and drive belts, it seemed to work very well and gave it the test of time, I kept this liquid in an empty nail varnish bottle as it had a built in small brush which now lived in my tool box. The time test was very successful and a busy machine might only need a re-application after 2-3 years, other machines much longer. I've been using this process ever since and it works just as well on auto changers, many of which are very reluctant even with a new idler, after treatment you now need to keep your fingers out of the way.

I passed this fix on to several friends and colleagues and was referred to as "magic mending fluid" and you use so little I only ever purchased the one can and I'm still using it.

Roger Grant

Accounts 2015

British Vintage Wireless Society
Statement of accounts for the year to 31st December 2015

		31st December 2015		31st December 2014
Receipts				
Subscriptions (net)		42894		40539
BVWATM friends group subscriptions/donations		890		-1757
Sale of publications		369		1039
Advertising		203		0
Insurance NVCF contribution to public lia ins		250		0
Capacitor sales		4505		4405
Deoxit sales		680		679
Meetings		1863		2861
Estate sales receipts		42573		51138
Valveman DVD sales		122		70
Donations		0		36
Bank interest		6		5
NVCF profit/(loss 2014)		2658		-250
Total receipts		97013		98765
Payments				
General expenses	3595		11474	
Stationery	584		1883	
Storage facilities	2520		2520	
Postage (net)	733		2968	
Meetings	7622		2822	
Bulletin costs including postage	20278		28905	
Estate sales payments	38305		53960	
Capacitor costs	3085		461	
Deoxit purchases	1099		549	
Valveman DVD sale proceeds transferred to BVWATM	0		230	
BVWATM friends group donations	347		0	
Other publication costs	115		639	
Total payments		-78283		106411
Surplus for the period (Loss 2014)		18730		-7646
Total assets at beginning of period		18452		26098
Total assets at end of period		37182		18452
Assets				
HSBC current account		23045		8979
HSBC deposit account		4232		2226
NVCF assets (held for the benefit of the B.V.W & T.V museum)		9905		7247
Total assets		37182		18452

At 31st December 2015 £31(2014 £926) was owed by the BVWS to the authors of various publications that the BVWS sell on behalf of these authors and NIL £ (2014 £1192) was owed to the beneficiaries of estate sales. These liabilities are not recognised in the accounts.
£9498.10 for the winter issue of the magazine was paid after date and will reflect in the 2016 accounts.
The accounts of the Society reflect the receipts and payments on a cash basis and do not reflect any prepaid or accrued income and expenditure. As an unicorporated club, all surplus is passed to members by way of bulletins, suppliments and events. At the same time a prudent asset balance is maintained in order to provide for the unexpected.

....
Treasurer

AUDITORS REPORT TO THE MEMBERS OF THE
BRITISH VINTAGE WIRELESS SOCIETY

We have examined the above Accounts and the attached Accounts of the National Vintage Communications fair for the year ended 31st December 2015 together with the accounting records and supporting documents and vouchers and confirm the same to be in accordance therewith.

MAAT

Anstey House,43 Stennels Close Coventry CV6 2JG

Hodgekins Accountancy

Accounts information courtesy of Greg Hewitt BVWS treasurer.

BVWS Spares Dept

DeoxIT D5 contact cleaner / lubricant £16.50
aerosol can. Not cheap – just the BEST.
Available at all BVWS events or by post for an additional £4.00

New manufacture high quality metallised polyester film capacitors to replace all old paper types in
vintage equipment. Ideally sized for re-stuffing

All capacitors are 630 Volt working
All prices are for packs of 50 components and include postage and packing

Available in mix-and-match packs of 50 within price band by post.
Available in smaller quantities at all BVWS events.

0.001μF	**Price band A**	**0.022μF**	**Price band B**
0.002μF	**Price band A**	**0.047μF**	**Price band B**
0.003μF	**Price band A**	**0.1μF**	**Price band B**
0.0047μF	**Price band A**	**0.22μF**	**Price band B**
0.01μF	**Price band A**		

Price band A is £25.50 (inc postage)
Price band B is £29.00 (inc postage)

Electrolytic smoothing capacitors, standard 'old-fashioned' size, 500 Volt DC working

8/8μF, 16/16μF, 32/32μF £7.00 each
50/50μF £9.00 each
16/32μF for DAC90A £9.00 each
60/250μF for TV22 £9.00
8/8μF screw–type, 16/16μF screw–type,
32/32μF screw–type £9.00 each
16/16 μF tubular axial £6.50
10μF tubular axial £4.00
22μF tubular axial £4.00
33 μF tubular axial £4.00
47 μF tubular axial £4.50
70 μF tubular axial £4.50

NEW smaller 25mm can types for re-stuffing original single electrolytic capacitors

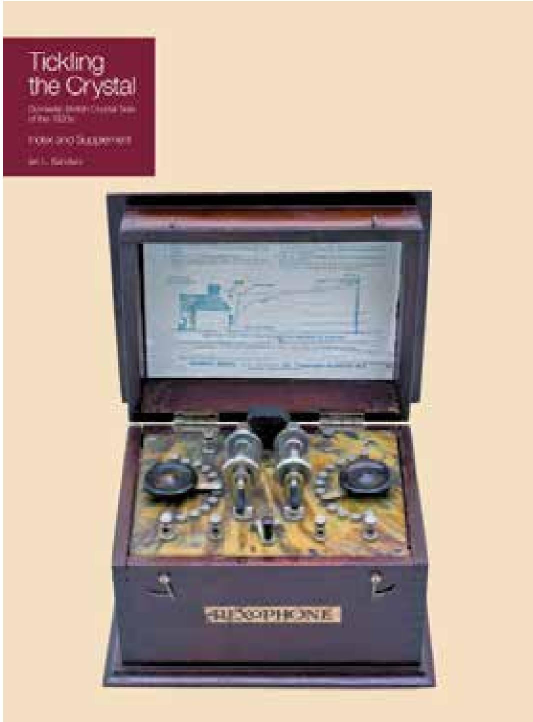
8μF, 16μF, 32μF, 47μF, 500Volt DC working £5.00 each

Postage and packing 1 – 4 caps £3.00 5 – 8 caps £4.50

All prices quoted are for BVWS members

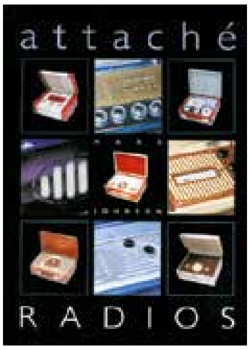
For non UK addresses, please contact Mike Barker for prices, (see below). All orders should be sent (with payment made out to BVWS) to: Mike Barker, Pound Cottage, Coate, Devizes, Wiltshire, SN10 3LG. Cheques payable to British Vintage Wireless Society. Please allow 14 days for processing, but usually quicker! The above capacitors are supplied as a BVWS member benefit. Anyone found to be reselling these items for profit will be expelled from the Society

BVWS Books



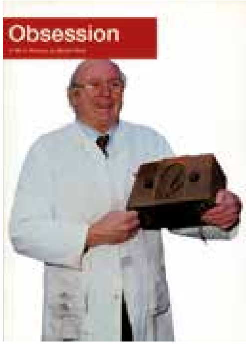
Tickling the Crystal
index and supplement
80 pages of GPO No. era British crystal sets. including comprehensive index listing sets in all five volumes of Tickling the Crystal
£11.95, £9.95 to BVWS members.
(+ £2.50 p&p UK) £3.50 EEC (rest of world £5.50)

Shareholders of the British Broadcasting Company
by Lorne Clark
68 pages. For the first time, a comprehensive listing of all of the companies, large and small, comprising the British Broadcasting Company - the forerunner to the British Broadcasting Corporation. Illustrated.
£10.95 (+ £2.50 p&p UK)
£3.50 EU (rest of world £5.50)



Attaché Radios
by Mark Johnson
An 80 page colour paperback guide to the Attaché portable
- Detailed specifications
- 140 radios in full colour
- Over 200 additional photos of sales literature, trade ads etc.

£12.00 (+ £2.50 p&p UK)
£3.50 EU (rest of world £5.50)

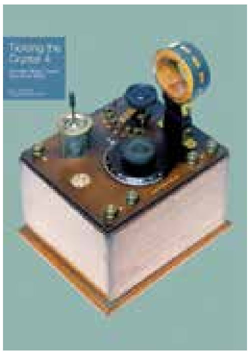


Obsession
by Gerry Wells
Growing up in the 1930s, young Gerry Wells preferred wireless to toys. He had a postwar career as a radio and TV engineer designing and managing amplifiers, PA's and TVs. He founded the British Vintage Wireless and Television Museum from the home where he was born. This is the story of one man's dedication to wireless
£6.00 196 pages paperback
(+ £2.50 p&p UK)
£3.50 EU (rest of world £5.50)

Tickling the Crystal
256 pages. Over 200 full-page photographs. £14.95 for BVWS members plus £7 p&p for UK, £13 EU
(rest of world £19)

Tickling the Crystal 2
Limited, Only 750 copies printed. 208 pages. Over 125 full-page photographs. £29.95 (£24.95 for BVWS members) plus £7 p&p for UK, £13 EU (rest of world £19)

Tickling the Crystal 3
Limited, 500 copies printed. 240 pages of GPO No. era British crystal sets. Over 75 full-page photographs. £29.95 (£24.95 for BVWS members) plus £7 p&p for UK, £13 EU (rest of world £19)



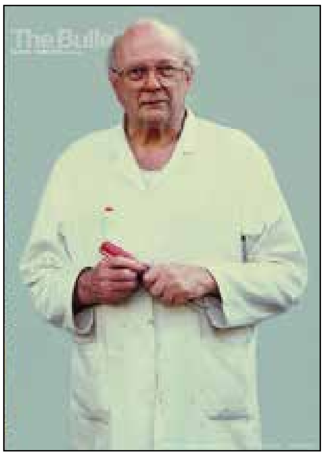
Tickling the Crystal 4
More Domestic British Crystal Sets of the 1920s. 280 pages of GPO No. era British crystal sets. Over 115 full-page photographs. £29.95 (£24.95 for BVWS members) plus £7 p&p for UK, £13 EU (rest of world £19)

Tickling the Crystal 5
More Domestic British Crystal Sets of the 1920s The final edition in Ian Sanders' thorough five volume set exploring GPO No. era British crystal sets. 252 pages/ of GPO No. era British £29.95 (£24.95 for BVWS members) plus £7 p&p for UK, £13 EU
(rest of world £19)

BVWS Books

Slipcase to house the first three volumes of Tickling the Crystal £9.95 Buy all three and get slipcase free! (postage £12 UK, £35 EEC, £55 US) BVWS members buy two and save £12 (postage £9 UK, £24 EEC £28 US)
Cheques payable to British Vintage Wireless Society

Mike Barker, Pound Cottage, Coate, Devizes, Wiltshire, SN10 3LG


The Bulletin


The Bulletin

1/8 page advertisements cost £22.50 - 1/4 page advertisements cost £45 - 1/2 page advertisements cost £90 - full page advertisements cost £180.
Contact editor_bulletin@bvws.org.uk for more infomration.

Events Diary

2016 Meetings

December 4th Royal Wootton Bassett

2017 Meetings

February 5th Special auction at Royal Wootton Bassett
February 19th Audiojumble
March 5th Harpenden
April 9th Golborne
May 14th National Vintage Communications Fair
Warwickshire Exhibition Centre CV31 1XN
June 3rd Garden Party at BVWATM
June 4th Swapmeet at the Cinema Museum, London
July 2nd Royal Wootton Bassett
August 6th Punnetts Town
September 10th Murphy Day at Mill Green Museum
September 24th Harpenden
October 1st Audiojumble
November 12th Golborne
December 3rd Royal Wootton Bassett

GPO Numbers
Martyn Bennett is the custodian of the BVWS GPO Registration Numbers list. As many members know, the project of assembling this list was started in the early days of the BVWS and was carried on by the late Pat Leggatt. Members are strongly urged to help build the list, whenever they get the opportunity, particularly as it is something that will help with the identification of vintage wireless in years to come. The list is by no means complete and the GPO no longer have a record of the numbers granted to wireless manufacturers. The BVWS Handbook contains the current listings - one in numerical order and one ordered by name. Please let Martyn have any additions, or suggestions for corrections, by mail or over the phone.
Martyn Bennett, 58 Church Road, Fleet, Hampshire GU51 4LY
telephone: 01252-613660 e-mail: martyb@globalnet.co.uk

The British Vintage Wireless and Television Museum:
For location and phone see advert in Bulletin.
Harpenden: Harpenden Public Halls, Southdown Rd. Harpenden.
Doors open at 9:30, tickets for sale from 09:00, Auction at 13:00.
Contact Vic Williamson, 01582 593102
Audiojumble: The Angel Leisure Centre, Tonbridge, Kent.
Enquiries, 07873 862031 info@audiojumble.co.uk
NVCF: National Vintage Communications Fair
For more information visit: www.nvcf.co.uk
Royal Wootton Bassett: The Memorial Hall, Station Rd.
Wootton Bassett. Nr. Swindon (J16/M4). Doors open 10:00.
Contact Mike Barker, 01380 860787
Golborne: Golborne Parkside Sports & Community Club.
Rivington Avenue, Golborne, Warrington. WA3 3HG
contact Mark Ryding 07861 234364
Punnetts Town: Punnetts Town Village Hall, Heathfield,
East Sussex TN21 9DS (opposite school)
Contact John Howes 01435 830736
Mill Green Museum: Bush Hall Lane, Mill Green, Hatfield, AL9 5PD

For more details with maps to locations see the BVWS Website:
www.bvws.org.uk/events/locations.htm

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